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Featuring

Massachusetts Highways

Vol. XVI No. 10

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CONTENTS

PAPERS AND DISCUSSIONS

PAGE

Massachusetts Highways. *Arthur W. Dean* 493

Discussion 550

OF GENERAL INTEREST

Ice used in Erection of Flat-bottomed Tanks. *Waldo F. Pike* 554

Testing Temperature affects Strength of Concrete. *Miles N. Clair* 555

Proceedings of the Society 555

Book Review 558

CONTENTS AND INDEX — Volume XVI, 1929

Contents iii

Index vii

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JOURNAL OF THE

BOSTON SOCIETY OF CIVIL ENGINEERS

Volume XVI DECEMBER, 1929 Number 10

"MASSACHUSETTS HIGHWAYS"

By Arthur W. Dean,* Member, Boston Society of Civil Engineers

Massachusetts highways, as a comprehensive term, may be understood to include all highways in the State. A distinction, however, is made in which the State highways are differentiated from the roads and streets of towns and cities. The Department of Public Works has definite responsibilities regarding the construction and maintenance of the former and more discretionary responsibilities regarding the improvement of the latter in co-operation with the municipalities.

The magnitude of the highway problems may be represented by the mileage figures. It is estimated that there are 22,760 miles of town and city roads, and 1,630 miles of State highways. This mileage of State highways is the total of various lengths throughout the State, which the Commonwealth has designated as State highways. These, originally, were city or town roads, but they have been deemed of sufficient importance from the standpoint of through travel to warrant improvement and expenditure by the State.

The economic pressure for improved routes for intercommunication is not a new condition incident to present-day types of vehicles. Each period in history has had its problems.

The Turnpike Era

The turnpike era in Massachusetts, coincident with that in the other states, was the outgrowth of this demand for travel routes one hundred to one hundred and fifty years ago. This era commenced in Massachu-

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* Chief Engineer, Massachusetts Department of Public Works.

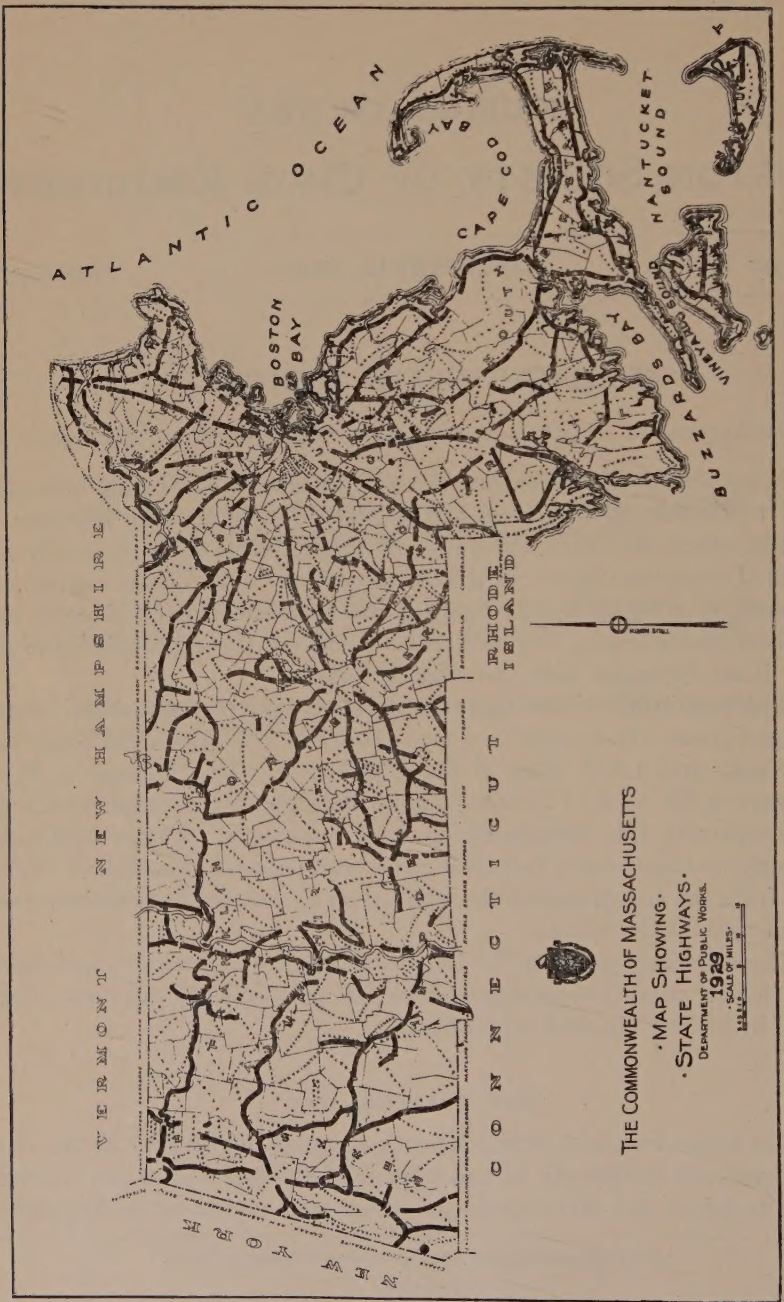

FIG. 1. — MASSACHUSETTS STATE HIGHWAYS AS LAID OUT TO END OF 1929

setts in 1796, when the General Court passed the first act for the incorporation of a private company for the construction and maintenance of a toll highway, designated as a turnpike.

The purpose of these toll roads was to provide roads, which towns declined, or felt unable, to finance. The expectation of a substantial return from investment was sufficient to interest private capital, and the circumstance of substantial monopoly in a locality made such an investment more attractive. Each corporation, however, was made subject to dissolution, when its first investment had been repaid, plus 12 per cent interest. This form of investment made its strongest appeal during a period of about twenty to twenty-five years, until it became evident how far short of the expected amount the returns materialized.

Many years ago these roads ceased to be operated as private enterprises and became public ways. In general, it may be said that the turnpike era ended about 1850, although a few toll roads and bridges existed until some years later.

At the present time there are no toll roads or bridges in Massachusetts. An act passed by the Legislature in 1845 authorized the county commissioners to lay out any turnpike as a public way if they deemed it a public convenience and necessity.

The present-day revival of interest in this method of financing special highways, bridges and tunnels should benefit from the experiences of a hundred years ago, which indicate that such enterprises must have proven and not imagined demands for the employment of private capital for such purposes, in view of the mounting income derived from the more popular forms of motor vehicle taxation.

Early Turnpikes

The first turnpike in Massachusetts, authorized by the Legislature in 1796, was a part of the route from Boston to New York, via Worcester and Springfield, and the particular section was that in Warren and Palmer. This has been designated as the First Massachusetts Turnpike.

During the next eighteen years 97 corporations were chartered for construction and maintenance of turnpikes, but subsequent to 1814 only a few were authorized. In all, there were 118 acts passed authorizing such ways, not all of which were ever constructed.

The Second Massachusetts Turnpike was the road extending from the west line of Charlemont to the west base of Hoosuck (or Florida) Mountain in the original township of Adams. This followed closely the route of the line of the old Indian trail known as the Mohawk Trail. In

1914 the Massachusetts Highway Commission completed the construction of a State highway over nearly the same line.

The Newburyport Turnpike was chartered in 1803. The instructions given to the engineers who built this road were to build straight, south 24° west.

This road, about 26 miles in length, was opened to travel on February 11, 1805. Its cost was nearly half a million dollars. The road never became a financial success. The construction of the Eastern Railroad to Newburyport in 1840 offered too great a competition. By 1852 the whole road became a public road, free from tolls.

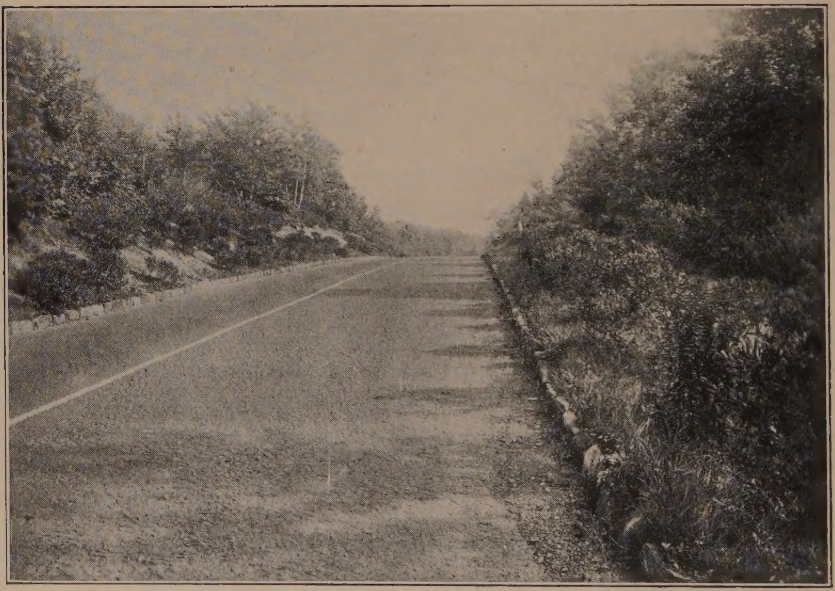

FIG. 2. — BITUMINOUS MACADAM, NON-SKID TYPE OF SURFACE

Vertical curve, cobble edging, shrub planting on slopes and center traffic line

THE TURNPIKE HERITAGE

Many of these turnpikes are now parts of present-day routes of travel. Mention is made of them because they are factors in our modern problems, in some cases working to advantage, and in other cases involving costly construction and reconstruction. Some of these pikes avoided the populous centers, and, because of that fact, became unused, or little used, ways. In these cases the present-day demand for high-speed roads may take advantage of this peculiarity, as, for example, certain portions of the proposed Worcester Turnpike construction.

The public, in thought, refer to the picturesque days of the turnpikes, but today would not be satisfied with the old conditions of travel. The demand is for greater widths of pavement, curve and grade eliminations, and high-speed roads.

The State is endeavoring to provide such facilities for transportation, and in addition is constantly improving the roadsides in order to retain or develop beautiful vistas, having in mind the passing enjoyment of the traveler.

Origin of Massachusetts Highway Commission

The participation of the State of Massachusetts in the matter of the improvement of highways resulted from the activity of progressive citizens and organizations in presenting the needs for better roads and in repeated appeals to the State Legislatures of forty or more years ago. As a result of the interest of these advocates of highway improvement and co-operation on the part of the State, an act * was passed in 1892, entitled "An Act to Establish a Commission to Improve the Highways of this Commonwealth."

This Commission, appointed by Governor Russell in 1892, consisted of Mr. George A. Perkins, who was a "good roads advocate," and who represented the bicycle clubs and riders of the State; Mr. William E. McClintock, who had been city engineer for the city of Chelsea, who was an engineer by profession, and as a private engineer had been building highways in various cities and towns in the Commonwealth; and Prof. Nathaniel S. Shaler, who was Dean of the Lawrence Scientific School, Harvard College, and an authority on geology and materials suitable for road building, as well as on topographical and geological surveys.

The Commission was instructed to investigate the best and most practical methods for the construction and maintenance of highways, the establishment of State or county highways, and to make recommendations as to their construction and maintenance, routes, approximate cost, and also to consider the geological formation of the State in so far as it related to materials suitable and proper for road building.

The term of office of the members of this Commission was to expire on the first Wednesday of February, 1893, on or before which date the Commission was ordered to report fully, with plans and estimates, their recommendations to the Legislature.

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* Chapter 338, Acts of 1892.

The report contains a most interesting and exhaustive account of the topography of Massachusetts with relation to the materials available in the various parts of the State for road building; the soil and subsoil conditions, which would make road building difficult and would require special methods of treatment in various parts of the State; a very complete report on road materials available in the State, and the values of each from the point of view of both construction and maintenance and their ability to stand traffic; and a more or less complete survey of the conditions of the Massachusetts roads.

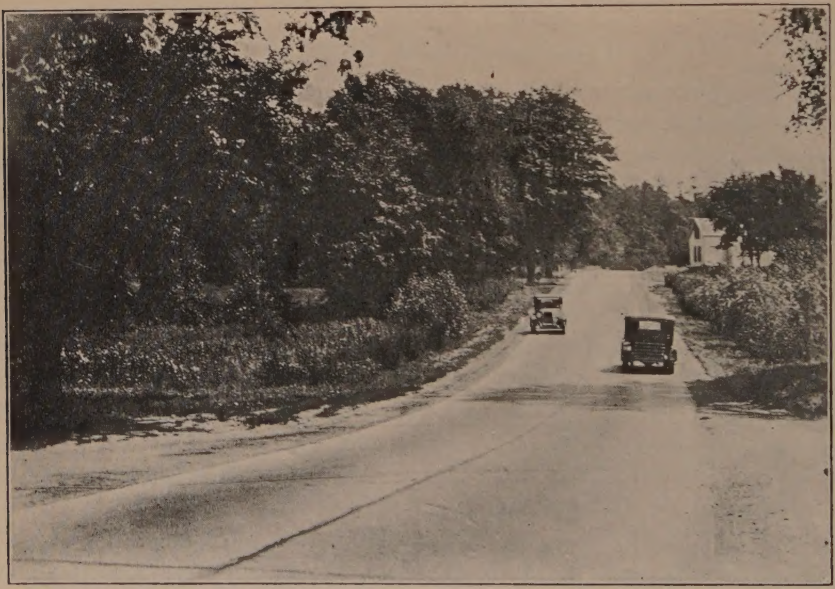

Fig. 3. — Cement Concrete Pavement, with Gravel Shoulders and Border Planting

In a very practical way the Commission obtained a photographic record of the actual condition of the principal roads in various parts of the Commonwealth, covering about 600 miles of highways, including portions of every county except Nantucket.

The report showed that the roads throughout the Commonwealth, outside of city and town streets, were in a deplorable condition, and could not be improved unless either the counties or the State provided a large part of the necessary funds.

It made quite an exhaustive study of the economics of road construction and improvement, which showed that not only the building of good roads would pay, but that the saving in the cost of transportation would amount to a large sum of money every year.

The Commission also made an actual traffic count on some of the main roads leading into Boston, showing the amount and weight of traffic at that time, and the saving that could be effected if the roads were improved, with a comprehensive treatise on the methods of construction of city streets built of various materials, including stone block, wood block and asphalt, and the comparative cost of transporting heavy loads over the same.

This preliminary report emphasized the great importance of foundation and drainage, as it was shown conclusively how essential it was to have a road constructed (no matter what its surface was) upon a suitable, strong, dry and adequate foundation; that a road could not be successfully built upon clay or loam or any fibrous or other soil, which either would hold water or would remain wet by capillary attraction; and that the subsoil foundation must be drained. Particular stress was laid upon the necessity of keeping the foundations dry and of making the top waterproof.

Massachusetts Highway Commission

The form of legislation recommended by that Commission was favorably passed by the Legislature and became chapter 476 of the Acts of 1893, thereby creating the Massachusetts Highway Commission.

The three members of the Special Commission were appointed as the first members of the Massachusetts Highway Commission, and were appointed for terms of one, two and three years, respectively, but reappointments were to be made for a term of three years, thus insuring continuity in office and in policies regarding the standard construction, etc. The Commission was authorized to appoint its engineer and to employ experts and necessary clerical and engineering assistants.

Previous to this time the construction and maintenance of highways in the towns and cities throughout the State were a function of the local officers of the municipalities. Such local control of highway work generally resulted in the adoption of methods not well adapted to produce the most economical construction and maintenance, and in some instances in the following of local practice in the use of road building material without a definite study of the best use of the same. The expenditures by the cities and towns for road work were probably as much as the authorities felt warranted in making, and it was realized that the improvement of the roads must come about by further expenditures. That could be accomplished only by some method of State aid, which would, in effect, result in the larger centers of the Commonwealth contributing towards the cost of work in smaller localities.

Powers and Duties

The powers and duties of the Highway Commission included the following: To compile statistics relating to the public roads of counties, cities and towns, and to make such investigations relating to them as they considered expedient. They were to be consulted without charge by the officers of counties, cities or towns having charge of and authority over public roads, and were to advise them relative to construction, repair, alteration or maintenance of their roads, but such advice did not relieve those officers from their legal duties and obligations in regard to them. They were required to prepare maps of the Commonwealth showing city, town and county boundaries and also the public roads, particularly the State highways.

The Commission was required to make annual reports to the Legislature, to consider petitions from the towns for the laying out of State highways, and, after laying out said ways, to construct and maintain them at the expense of the Commonwealth. The Commission was also authorized to set out shade trees at suitable places along State highways. The law provided that all construction of State highways should be fairly apportioned among the counties, and that not more than ten miles of State highway should be constructed in any one county without the previous approval of the Governor and Council. For the maintenance of State highways the Commission had authority to make contracts with the towns or with any person or firms without advertising for bids.

Study of Highway Materials

In 1894 a study of the road materials available in the various parts of the State was made, and the result plotted on topographical sheets. This work was done by the late Logan Waller Page, who afterward became Director of the Bureau of Public Roads of the Department of Agriculture, Washington. Mr. Page made elaborate tests of the various road materials, using testing machines devised for this purpose. These tests or similar ones have been continued down to the present day.

In its very first years the Massachusetts Highway Commission drew specifications for the construction of a waterbound macadam road by a method which, so far as can be ascertained, they originated. These specifications were the result of a very careful and analytical study and experimentation with gravel, stone, chips, dust and the method of rolling, and were a guide for their successors.

Since the organization of the Massachusetts Highway Commission, the roads constructed by it have been built to conform to standard plans and approved methods of construction.

EARLY APPROPRIATIONS

From the appropriation of $300,000 made by the Legislature in 1894 the sum of $9,000 was set aside for office expenses, salaries, surveys and general executive work, and the balance, $291,000, was allotted for road construction, the plan adopted embracing the acceptance of ways which might, on account of their importance and poor condition, if taken over as State highways and properly improved and maintained, afford the greatest relief to interested communities. Owing to the small amount of the appropriation, as compared with the number of calls for aid, it was deemed best at the outset to limit the amount of road to be built in any city or town to a maximum of about two miles, or to the length which

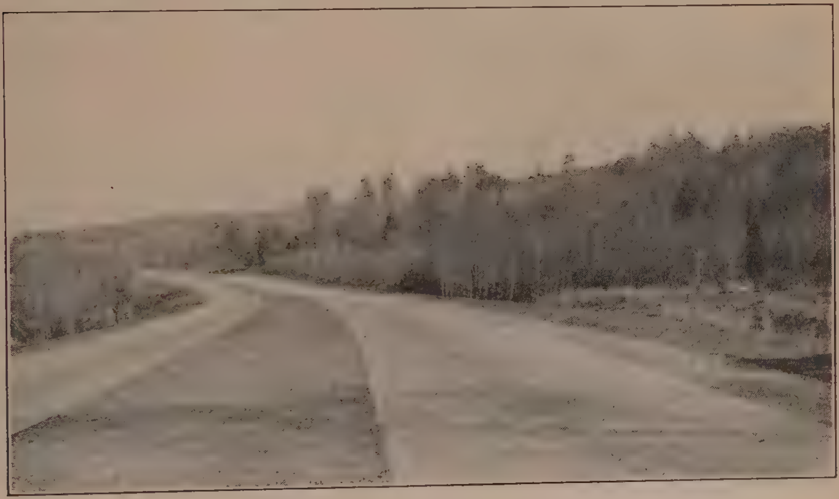

FIG. 4. — STATE HIGHWAY IN SUDBURY, "HENRY FORD ROAD"

Dual type pavement; two outer strips 10 feet wide, reinforced concrete; center strip 10 feet wide, bituminous macadam would afford substantial relief to the community and serve also as an object lesson, showing the proper method of highway construction. While this brought about a fragmentary distribution of the State highways, no other plan could be devised which would meet the requirements of the law or the many appeals for highway improvements.

EARLY CONSTRUCTION

The first State highway layout and contract were made in the town of Ashby.

Because of the limited funds available the Commission required the local authorities to secure from the abutting owners releases from land and grade damages before voting to make the layout.

The cities and towns co-operated in every possible way, some appropriating money to build their own village streets, and others purchasing and furnishing road machinery.

POLICY ESTABLISHED

In the second and subsequent years each piece of road laid out by the Commission was intended to form a part of an extended system, the object being to unite the larger cities and to accommodate the local as well as more extended travel with continuous highways.

In 1897 the Commission defined the policy to be followed in the construction of State roads: first, that the most important of the many needs was that which related to the connection of centers of business; second, the connection of agricultural areas and of smaller and less populous towns with a large city or center of dense population, with which they had intimate business relations; and third, the connection with railroads and waterways of the towns remote therefrom; with the ultimate intention of grouping these roads so as to make continuous State highways throughout the Commonwealth.

In the year 1900 an act was passed requiring the towns and cities to reimburse the Commonwealth to the extent of a sum not exceeding $50 per mile of the amount expended for the repairs to State highways. In this year the Commission was authorized to alter the location of State highways previously laid out. Legislation was also passed providing that of the amount appropriated each year for the construction and repair of State highways, 5 per cent should be expended in constructing and repairing highways in towns in which no State highway had been built. This act was amended in 1901 to include only towns having a valuation of $1,000,000 or less, and to include towns having State highways.

INFLUENCE OF MOTOR VEHICLES

In 1905 the Commission experimented with the use of oil in the treatment of sand roads on Cape Cod, and in 1907 commenced to use oils and tars to lay the dust due to the automobile traffic, and the following year used asphalt and tar as binders in the construction of highways.

In 1909 the increasing use of automobiles confirmed the Commission in the view that it had become necessary to adopt the use of a binder which would prevent the disintegration of the roads by the rubber tires of the motor vehicles. Consequently, experiments on a very large scale were conducted with asphalt and tar. For many of the roads a comparatively inexpensive surface treatment of bituminous binder with stone screenings, gravel or sand was considered a distinct advantage.

TRAFFIC COUNTS

The traffic on the State highways, particularly the automobile traffic, had in 1909 become an important factor in the highway maintenance problems. In that year a traffic census or count was made in August at more than two hundred stations, and again in October, to determine the volume of traffic passing these designated stations in a day. At intervals of three years a similar census has been taken at various points, wherever it was deemed advisable to get a record of traffic. These traffic counts have a value in relation to the design of the highways, and in a general way indicate the growth of traffic over the period of years for which they have been taken.

SMALL TOWNS

In 1912 the Legislature authorized the expenditure during the subsequent five years of $1,000,000 a year for the construction of State highways and improvement of small town roads. This made available $50,000 a year for the improvement of roads in towns of less than $1,000,000 valuation, which were not required to make any contribution; a like amount for towns of less than $1,000,000 valuation, which contribute an equal amount; and an additional amount of $50,000 for towns of over $1,000,000 valuation, these towns being required to contribute an amount equal to the Commission's allotment. The importance of this work in the small towns, with the proper methods and supervision and the advice given to the towns for the improvement of their roads, was considered valuable work, and furnished an example for such construction as the towns might do on their own account.

SPECIAL BRIDGES

In 1912 two of the largest bridges in the State were placed, by legislative act, in charge of the Highway Commission, namely, the bridge over the Merrimack River, between the city of Newburyport and the town of Salisbury, and the bridge over Taunton Great River, between the city of Fall River and the town of Somerset. This legislation was a new departure from the former policy of the Commonwealth. Originally, many of the larger bridges were toll bridges built and maintained by bridge corporations. After the charters of these corporations expired, these bridges were made free, and the expense of maintaining them was placed on the county or towns and cities in which they were located. A number of special acts have been passed from time to time for the building of several bridges and dividing expenses in many ways among the localities and municipalities affected. In only a few instances had the Commonwealth paid any part of such expense, and then only a small part. The Commission felt that an extension of the established policy would require the Commonwealth to maintain large and expensive bridges on the main through routes of travel, and involve an expenditure by the Commonwealth several times as large as the amount appropriated for the maintenance of State highways.

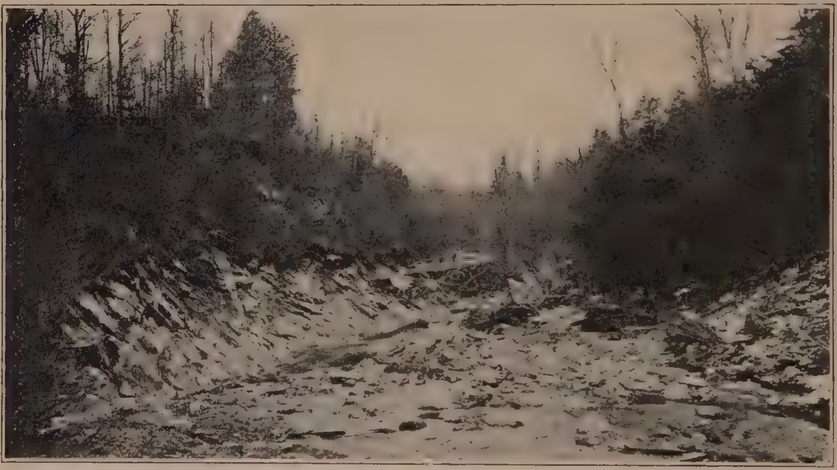

FIG. 5. — STATE HIGHWAY IN BECKET, BELOW LYMAN'S MILLS, WASHED OUT BY FLOOD OF NOVEMBER, 1927 (See Fig. 6)

Five Western Counties

In 1915 the Commission was authorized and directed to lay out, construct and complete within four years certain specific highways situated in the towns of the five western counties of the State.

A bond issue of $2,000,000 was authorized for this work, and repayment to the Commonwealth by these counties of amounts equal to one-fourth of the expenditure in such counties was required within six years, but such payments were to be used for repairing these roads or others in the towns of those counties.

Personnel, Massachusetts Highway Commission

The personnel of the Massachusetts Highway Commission from 1893 to 1919 was as follows:

George A. Perkins was elected first chairman of the new Commission. When he retired, in 1896, Governor Greenhalge appointed Thomas C. Mendenhall of Worcester, who was also elected chairman. Professor Shaler retired in 1898, and Governor Wolcott named Charles W. Ross of Newton in his place. Dr. Mendenhall remained as chairman until 1900, when both he and Mr. Ross retired. Governor Crane thereupon appointed Harold Parker of Lancaster and John H. Manning of Pittsfield, and Mr. McClintock was elected chairman.

The Commission as then organized served until July, 1908, when Mr. McClintock resigned, and Acting Governor Draper appointed William D. Sohier of Beverly. Mr. Parker was designated as chairman. In June, 1909, Mr. Manning died, and Governor Draper appointed Frank D. Kemp of Springfield to succeed him. Mr. Parker resigned in 1911.

In 1912 Governor Foss named James W. Synan to fill the vacancy caused by the resignation of Mr. Parker, and designated Colonel Sohier as chairman. From that year until December 1, 1919, when the Highway Commission was merged with the Commission on Waterways and Public Lands forming the Department of Public Works, the personnel of the Board remained unchanged. From the organization of the Commission, in 1893, until the end of its activities, in 1919, there were but ten Commissioners.

The Department of Public Works

By an amendment to the Constitution, which was accepted by the people in 1918, the Legislature was required to reorganize the executive and administrative work of the Commonwealth into not more than twenty departments. This mandate was made effective by the passage of legislation, chapter 350 * of the General Acts of 1919. By this act the Massachusetts Highway Commission and the Commission on Waterways and Public Lands were abolished, and as a successor to them there was created the Department of Public Works. This Department was to be in charge of a Commissioner and four Associate Commissioners, two to be in charge of the Division of Highways, which thereby succeeded the former Massachusetts Highway Commission, and two to be in charge of the Division of Waterways and Public Lands, successor to the former Commission on Waterways and Public Lands, the Commissioner and Associate Commissioners being appointed by the Governor, with the consent of the Council.

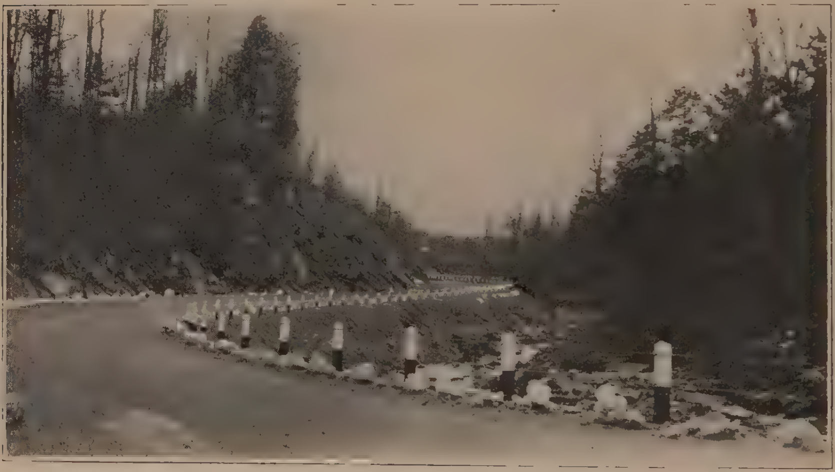

FIG. 6. — STATE HIGHWAY IN BECKET, BELOW LYMAN'S MILLS, RECONSTRUCTED IN 1928, BITUMINOUS MACADAM (See Fig. 5)

Under the provisions of that act, John N. Cole of Andover was appointed Commissioner of Public Works, and Frank D. Kemp of Springfield and James W. Synan of Pittsfield were appointed Associate Commissioners of the Division of Highways. Mr. Cole died October 18, 1922, and was succeeded by William F. Williams of New Bedford on December 1, 1922. Frank D. Kemp resigned June 14, 1922, being replaced by

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* This act later became chapter 16, General Laws of Massachusetts, enacted December 22, 1920, effective January 1, 1921.

Frank E. Lyman of Easthampton. James W. Synan died June 27, 1926, and the vacancy was not filled.

Chapter 297 of the Acts of 1927, in effect July 23 of that year, consolidating the two divisions into one department, provided for a Commissioner of Public Works, with only two Associate Commissioners replacing the four Associate Commissioners.

William F. Williams continued as Commissioner of Public Works, with Richard K. Hale, a former Associate Commissioner in the Division of Waterways and Public Lands, and Frank E. Lyman, former Associate Commissioner in the Division of Highways, as Associate Commissioners, until December 26, 1928, when he resigned. Mr. Lyman was appointed Commissioner and Herman A. MacDonald of Beverly was appointed as Associate Commissioner in place of Mr. Lyman, and Richard K. Hale remained in office as Associate Commissioner.

Engineering Organization

The functions of the Department, being the admixture of the powers and duties of the former Massachusetts Highway Commission and the Commission on Waterways and Public Lands, determine the form of the engineering organization. The consolidation of these two Commissions made possible the centralized direction of the most important engineering undertakings of the Commonwealth, so that there is one Chief Engineer for the Department.

For carrying out the engineering work of the Department there are several groups, whose duties are interrelated, and who report to the Chief Engineer.

For highways, there are seven District Highway Engineers, each being in responsible charge of one of the districts into which the State has been divided. Each District Highway Engineer is in charge of a district office in which are employed the necessary clerical and engineering assistants, whose duties are similar in all districts, relating to the construction and maintenance of the State highways and bridges and to such improvements of highways, other than State highways, as are carried on in co-operation with the cities and towns.

For Waterways, there are two District Waterways Engineers, reporting to the Chief Engineer. The duties of these engineers, however, are not involved in highway matters, unless the highway work affects tidewaters or certain rivers and great ponds.

Another group, reporting to the Chief Engineer, is designed to have definite responsibility for certain phases of the highway work. This group includes the Project Engineer, the Construction Engineer, the Maintenance Engineer and the Bridge Engineer. The titles of these engineers are generally descriptive of their duties.

The Project Engineer has charge of all engineering work relating to the stages of the work involving the investigations for highway construction; in brief, the design of highways, including, of course, the surveys, determination of locations, lines and grade, and preparations of plans, estimates and contracts.

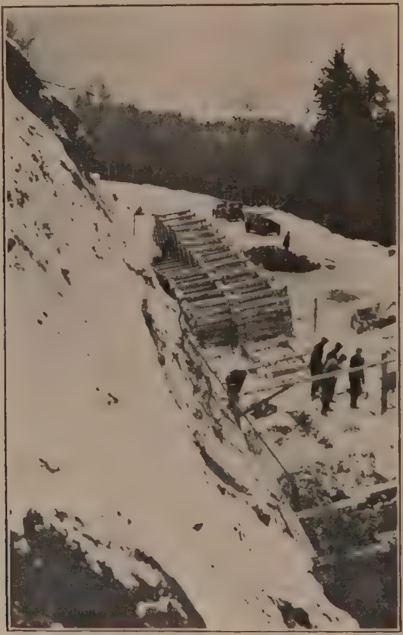

FIG. 7. — STATE HIGHWAY, WILLIAMSTOWN, PETERSBURG MOUNTAIN ROAD

Concrete crib under construction

The Construction Engineer's responsibility covers the supervision of the contracts for construction and reconstruction of highways, and the preparation of estimates of work done under these contracts; in brief, it includes that phase of the work from the time the contract is awarded until the finished highway is accepted by the Department.

The Maintenance Engineer's duties include the maintenance of all the State highways after completion of their construction, — surface maintenance, and repairs, drainage, snow removal, roadside development, operation and traffic matters, signs and signals, route marking, etc.

The Bridge Engineer has supervision of the design and construction of bridges built by the Department, and the investigations, for the Department, of plans and specifications for all bridges having spans more than ten feet, which are to be built on any public way by any party other than the State.

These four engineers, while reporting to the Chief Engineer, also have authority to direct their work through the organizations of the several district offices.

The entire engineering force of the Department consists of over 500 engineers, besides the necessary superintendents, clerks and stenographers.

FUNCTIONS OF THE DEPARTMENT OF PUBLIC WORKS *

Laying out State Highways

As a prerequisite to the laying out of State highways, a written petition may be presented by aldermen, selectmen or county commissioners to the Department stating that public convenience and necessity require that the Commonwealth lay out and take charge of a new or existing way as a State highway. If the Department determines that such a way be taken charge of by the Commonwealth, a copy of the plan, petition and certificate declaring that it has laid out a certain way as a State highway and taken charge of such way are filed in the offices of the county commissioners and town clerk.

Taking of Land for State Highways

If it is necessary to acquire land for the purposes of a State highway outside of the limits of an existing public way the Department may take such land by eminent domain as provided in chapter 79 of the General Laws. The mayor, if so authorized by the aldermen, or the selectmen, if so authorized by the town, may stipulate in writing in behalf of the city or town to indemnify and save harmless the Commonwealth against all claims and demands for damages which may be sustained by any persons whose property has been taken for, or has been injured by, the laying out or alteration of any highway which the Department proposes to lay out and construct, or alter, as a State highway, and such city and town thereupon becomes liable ultimately for the amount of any verdict against the Commonwealth for such damage and costs.

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* Chapters 16, 81 and 90 of the General Laws of Massachusetts.

Discontinuance and Abandonment

The Department may discontinue as a State highway any way or section of way laid out and constructed, and such discontinued way, or section, thereafter becomes a town way; also, the Department may abandon any land or rights in land taken or acquired by it, and such abandonment shall revest the title to the land or rights abandoned in the persons in whom it was vested at the time of taking, or their successors.

Contracts for Construction of State Highways

State highways are constructed by the Department at the expense of the Commonwealth. A city or town, within which a State highway lies, may contract with the Department for the construction of such highway within its limits, or the town may waive its right, or, if it desires to undertake such construction work, it must elect so to do within ten days of the notice from the Department that it is ready to construct such highway. The Department then may advertise for the construction of the highway, the contract for which must be approved by the Governor and Council.

Improvement of Ways not State Highways

The Department may, after receiving a petition therefor, construct or improve any particular way which is not a State highway when money is appropriated by the General Court for this purpose, and such improvement in regard to location and detail is left to the discretion of the Department. A way so improved does not thereby become a State highway unless so laid out in the usual procedure.

Maintenance of Certain Ways Improved by State Funds

Any public way or portion thereof which has been constructed or improved in whole, or in part, with money furnished by the Commonwealth, and which has not been laid out as a State highway, must be kept and maintained in good condition and repair by the town in which such a way lies. If such maintenance is not performed by the city or town, the Department may proceed to have such repairs or improvements made, the cost of which is assessed upon the delinquent city or town.

Repair and Improvement of Public Ways in Small Towns

In towns having valuations of less than $4,000,000, as established by the most recent valuation made for the purposes of apportioning the State Tax, and in which the proportionate amount paid by such towns of every million dollars of such tax as so established, divided by the number of miles of such public highways, — known as the "road mileage ratio", — is less than $12, there may be expended for the repair and improvement of public ways, other than State highways, such sums as the General Court may appropriate; provided, that such towns shall contribute or make available for use in connection therewith certain amounts per mile of such public ways, according to a schedule based on their road mileage ratio. These amounts to be paid by the towns vary from $15 to $150 per mile, according to a schedule defined in the act.

The amounts appropriated by the State and contributed by the towns are expended under the direction of the Department on such ways as the Department and the selectmen may agree upon. The mileage of such public ways in the towns entitled to these benefits are determined by the Department. The total mileage in the 166 towns included in this work amounts to about 8,050 miles.

Such expenditures, however, may be made only upon the written petitions of the selectmen. Furthermore, no work is done under these provisions in any district where dwelling houses or structures devoted to business are situated at intervals averaging less than 200 feet for a distance of a quarter of a mile.

These towns may contract with the Department for the performance of this work, or, at the request of the selectmen, the Department may have this work done by other persons as it may determine, the town's share of the cost of which is apportioned to the town.

Federal Aid

The Department is authorized to make all contracts and agreements and do all things necessary to co-operate with the United States in the construction and maintenance of so-called rural highways under the provisions of the Act of Congress approved July 11, 1916, entitled "An Act to Provide that the United States shall Aid the States in the Construction of Rural Post Roads, and for Other Purposes."

Any funds which may be available for the construction and maintenance of State highways may be used for this purpose, and the Department may, also, for the purpose of securing Federal Aid, use any money appropriated by a county, city or town for the construction of a way or any part of it for which Federal Aid may be secured, and may make contracts or agreements involving the expenditure of such money, provided the county commissioners, or the selectmen, or duly authorized officials of the city or town, have agreed, in writing, to pay the money thus appropriated upon the order of the Department. The Department may also maintain the roads constructed under this provision from any money appropriated by the General Court for the maintenance of State highways, or for the repair or maintenance of other public ways.

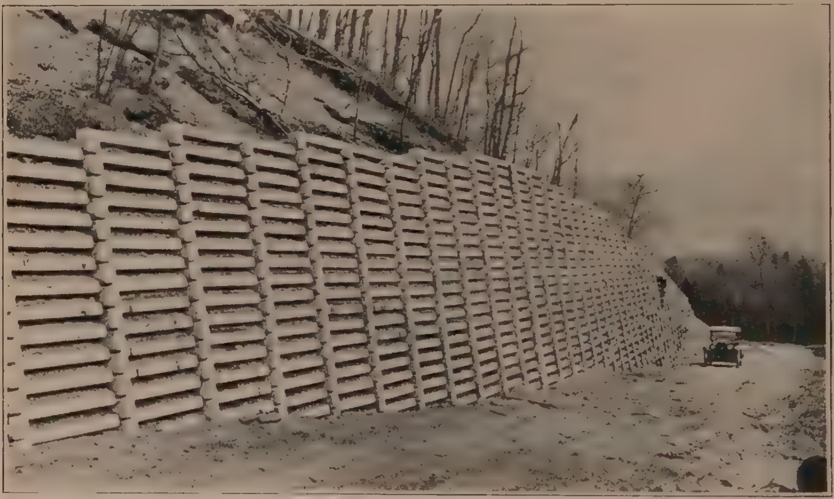

FIG. 8. — STATE HIGHWAY, WILLIAMSTOWN, PETERSBURG MOUNTAIN ROAD

Concrete crib, earth filled, 25 feet high

ELEMENTS IN THE DESIGN OF HIGHWAYS

Alignment and Gradient

The alignment of a highway in urban localities is generally not susceptible of much modification, because the way has been laid out and the lines fixed for many years. In outlying and rural districts alignment is the element given prior consideration.

The practice of the Department is to fix lines that do not require sharp turns and to provide open visibility, at the same time obtaining proper gradients. Alignment and gradient both become very serious and difficult problems under certain conditions, particularly in the hilly sections of the State, where cost is such an important factor. An ideal alignment would probably permit for curvature a radius of not less than 2,500 feet, and a gradient of not more than 6 per cent. It is often impossible to obtain these ideal conditions, consequently it is generally understood that the minimum radius shall be not less than 300 feet and a maximum gradient of 7 per cent, except under the most excessively expensive conditions.

Visibility at Summits

In the matter of grades, effort is always made to obtain good visibility at summits, and the State's standards require a clear view for a distance of 500 feet from a point 5 feet above the road surface. This it is impossible to obtain at all times, and 300 feet is generally admitted to be a minimum. This becomes an important factor in the case of bridge construction, particularly at the separation of grades at railroads and highways. Where visibility is necessarily short at certain summits, a widening is made of the roadway to permit of easier passage of vehicles in opposite directions.

Drainage

A third element and next in order is drainage, which is understood to include surface and subsurface drainage, the latter involving the subbase. Drainage must be perfectly taken care of, which means the satisfactory removal of surface water under all conditions and a satisfactory provision at all times for a suitable foundation. The latter requires the removing of ground water in such a manner and to such an extent that frost action and instability of foundation will be practically eliminated.

Types of Surface

The fourth element is type of surface, which should be determined by the kind, weight and volume of traffic. Width of surface enters into this and becomes a part of the problem. Obviously a wider surface distributes and spreads traffic, reducing its weight at any given point, and the lighter the traffic the lighter may be the type of pavement, within certain limitations. The principal types in use by this Department are reinforced cement concrete, bituminous macadam and bituminous concrete. Granite block, wood block and brick pavements, as well as waterbound macadam roads, are sometimes built. Reinforced cement concrete is generally used on roads of heaviest traffic; bituminous macadam and bituminous concrete on all the others, except roads that have very little traffic, where gravel or waterbound macadam is used. Bituminous macadam, when constructed of the best materials, is equal to, if not better than, the best types of bituminous concrete, in so far as its capacity for carrying weight of traffic and permanency are concerned. Several grades of bituminous concrete are constructed, and these vary in accordance with the weight and kind of traffic. There are three types in the State specifications. In general, what may be termed the lowest type of bituminous concrete is used where traffic is lightest, meaning thereby weight of vehicles, not volume of traffic, and it happens that this condition usually obtains in the vicinity of Cape Cod, where trucking has not yet become an important factor.

Width of location is another element, and it is probable that from now on few new State highways will be laid out less than 80 feet in width, where that can be done without excessive property damage. Nearly all of the main routes will be constructed with a surface at least 30 feet in width, and, to date, traffic does not seem to warrant building wider than that, except in metropolitan areas of dense traffic.

Ultimate State Highway System

The State highway system in its probable ultimate development includes the most important routes throughout the State, and must, by law, include both the primary and secondary routes of the Federal aid system. These important routes have been chosen and designated as State highway routes, the total mileage of which is 2,667 miles.

State Highways Laid Out

The actual mileage of State highways laid out, *i.e.*, the mileage now so designated, at the end of the fiscal year, November 30, 1928, was 1,609 miles, or about 60 per cent of the mileage of the State highway routes mentioned above. The balance of this mileage is therefore eligible for designation as State highways.

STATE HIGHWAY CONSTRUCTION

The mileage of State highways of different types of completed surfaces as they existed at the end of the fiscal year 1928 amounted to 1,587 miles. The following tabulation gives the mileage of the various types:

STATE HIGHWAY MILEAGE COMPLETED AT END OF 1928

TYPES OF SURFACES	Present Mileage Completed
Cement concrete	242.598
Bituminous concrete asphalt	219.904
Bituminous concrete tar	.697
Bituminous macadam asphalt	541.280
Bituminous macadam tar	199.646
Bituminous macadam hot oil	15.881
Waterbound macadam	242.118
Gravel	90.907
Dirt	7.121
Layer sand and oil	2.528
Granite block	2.469
Brick	.075
Wood block	.054
Plank	.0176
Dual	9.157
Miscellaneous	12.548
Total	1,587.000

In many cases the earlier types have been replaced by more suitable modern types. In the above tabulation, 1,216 miles are classified as modern types of pavements, and 371 miles as old types of pavement, which the Department plans to replace as rapidly as possible.

Of the modern types, the greatest mileage constructed has been of the bituminous macadam, being about 60 per cent of that mileage. Cement concrete pavement stands next in order; waterbound macadam stands third, but is being replaced by more durable modern types; bituminous concrete stands fourth on this list, but is no doubt the third most popular type of modern rural pavement.

The construction and reconstruction of State highways only, during the last fiscal year (1928), amounted to a total of 139 miles, the more important types of which were as follows:

TYPES OF SURFACES	Mileage Constructed
Bituminous macadam	99.5
Bituminous concrete	20.4
Cement concrete (reinforced)	10.0
Dual (two outer strips, cement concrete, center strip, bituminous macadam)	4.7

CONSTRUCTION OF TOWN AND COUNTY HIGHWAYS BY DEPARTMENT*

The construction of highways in co-operation with cities, towns and counties under the provisions of chapter 90, General Laws, is carried on in conformity with specifications prepared by and under the supervision of the Department. Counties do no construction work on highways, but their share is the meeting of their apportionment of the cost of the improvement. Cities and towns may contract to do this work, if that may be done to advantage, but work involving a considerable expenditure is, to greater advantage, performed under competitive contracts.

The construction of the roads under this chapter during 1928 was as follows:

MILEAGE CONSTRUCTED BY DEPARTMENT IN 1928, UNDER PROVISIONS OF CHAPTER 90 OF THE GENERAL LAWS

TYPES OF SURFACES	Miles
Cement concrete (reinforced)	5.214
Bituminous macadam	47.130
Bituminous concrete	14.731
Dual	.385
Waterbound macadam, bituminous surface treatment	.923
Gravel	43.817
Gravel, bituminous surface treatment	21.456
Earth	2.151
Total	139.315

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* Section 34, chapter 90 of the General Laws.

TOTAL MILEAGE CONSTRUCTED IN 1928

The total mileage of highways constructed by the Department during 1928, including the construction and reconstruction of State highways and town ways under provisions of chapter 90, was as follows:

	Miles
Construction of State highways	31.223
Reconstruction of State highways	107.825
Construction, town ways	139.315
Construction under special acts	1.612
Total	279.975

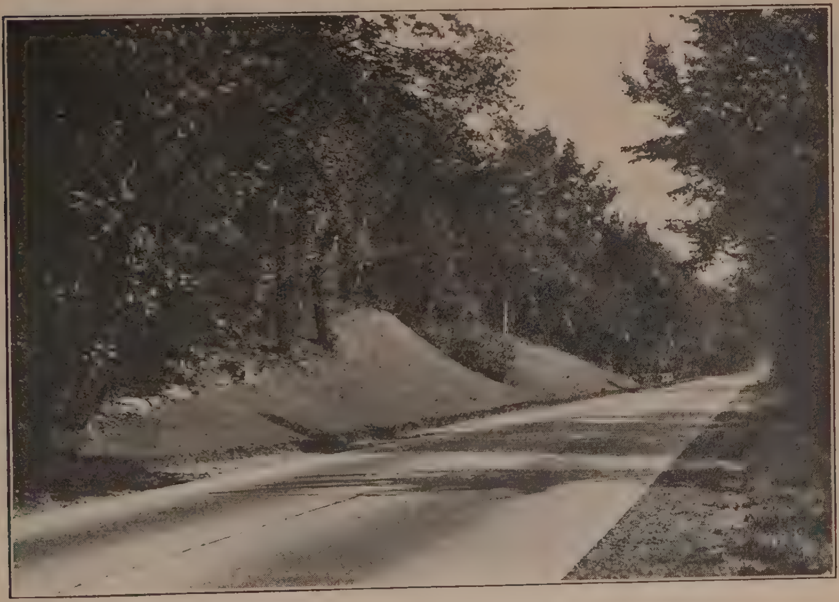

FIG. 9. — STATE HIGHWAY, LAKEVILLE

Reinforced cement concrete, gravel shoulders; maintenance, attractive grassed slopes and shrub planting in hollow

CEMENT CONCRETE PAVEMENT

Cement concrete pavement, although not so extensively used on Massachusetts State highways as the bituminous pavement, is admittedly the best of the three standard types. The first cost is considerably greater than the cost of bituminous macadam or bituminous concrete, except in a few localities where it is possible to secure materials suitable for concrete at a low cost, and where the cost of suitable broken stone for bituminous macadam is large on account of a long haul. The use of cement concrete by the State is limited in general to the primary routes where truck travel is very heavy and in excess of 1,000 vehicles per day, and then only where the subsoil conditions are stable. It is not used over swampy or other localities where there is liable to be settlement and consequent breaking up of the concrete.

Details of Cement Concrete Pavement

Cement concrete pavement which the Department is now building is constructed, as a rule, in slabs 10 feet wide and not over 60 feet long, with a uniform depth of 8 inches. These slabs are reinforced with ½-inch bar steel, the quantity of steel used weighing between 9 and 10 pounds to the square yard, the steel being placed 2 inches from the bottom of the slab. The concrete mix is 1:2:3½. This year, for the first time, the Department has been specifying washed gravel, where gravel aggregate is used. This gravel appears to have produced a stronger concrete, as the tests on beams and cylinders made this year indicate higher strength than in previous years.

As a rule, the concrete roads have been built 20 feet wide with a longitudinal joint in the center, the two slabs being tied together by ½-inch bar steel, or by dowels of ½-inch steel. The transverse joints are also tied together with dowels of ½-inch steel. These dowels are so placed that one end is free so that they can slip in the concrete without buckling when the concrete expands. Expansion joints ½-inch in width are put in the pavement between each slab at each transverse joint.

This year calcium chloride occasionally has been used in solution with the mixing water, and the concrete pavement has been opened to travel when a modulus of rupture of 500 pounds has been obtained, considering that this is equivalent to a compressive strength of 3,000 pounds per square inch. This value of 500 pounds modulus has been obtained, as a rule, in seven days.

Strength of Cement Concrete

The concrete laid during the last five years, that is, from 1924 to 1928, inclusive, produced the following average 28-day compressive strength; in 1924, 925 pounds; in 1925, 2,123 pounds; in 1926, 2,101 pounds; in 1927, 2,920 pounds; in 1928, 2,930 pounds. It is confidently expected that the tests will range between 3,000 and 3,500 pounds. It should be understood that these cylinders, which have been broken, were made in the field, and are not laboratory cylinders, and some of them have not been made as carefully as they should have been. If these cylinders had all been made in the laboratory, or by a laboratory man, they undoubtedly would have averaged higher in every case. The important point in considering the report of the cylinders tested from 1924 to 1928 is that the compressive strength of the concrete has increased more than 50 per cent in that period of five years. Another important consideration is that the average 14-day strength of concrete in 1927 and 1928 was much stronger than the average 28-day strength in 1924 and 1925. As a further advance, in 1929 it is found that with the use of calcium chloride, greater strength results, as a rule, at the 7-day test than was obtained in 1924 and 1925 in a period of 28 days.

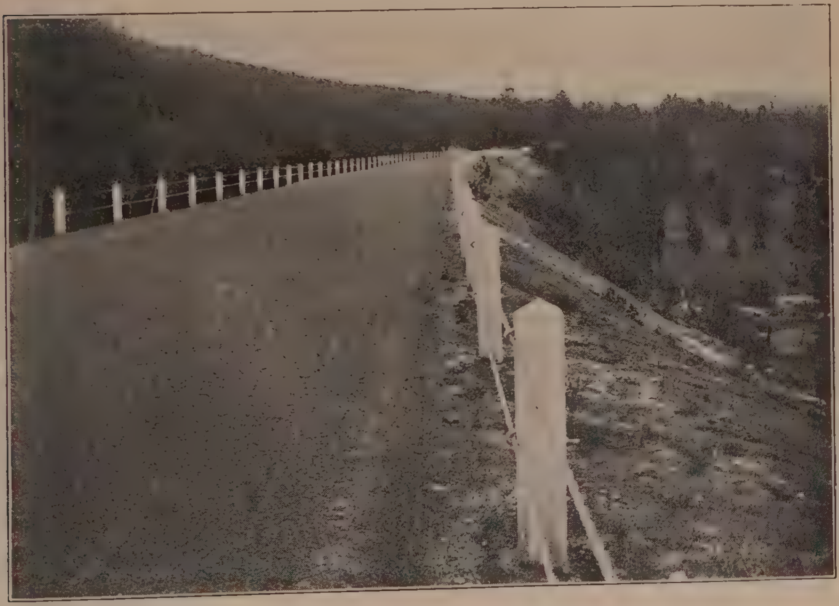

Fig. 10. — Bituminous Macadam, Mosaic Surface

Slopes ready for planting

Bituminous Macadam Pavement

Bituminous macadam pavement can be built with less equipment than either the cement concrete or bituminous concrete, and for that reason the competition is usually keener. This type of pavement, when properly built on suitable foundations, will carry almost unlimited volume of pleasure travel as well as a large volume of heavy trucking.

This pavement is being built 7 inches thick, 4½ inches of bottom stone, bonded or filled with sand or stone dust, and a 2½-inch top course of No. 1 broken stone, penetrated with 2½ gallons of asphalt, and sealed with ½ gallon of asphalt. The penetration course is usually specified to receive a gallon per square yard to every inch of depth that is being penetrated, so that a 3-inch penetration will require 3 gallons per square yard, and a 2-inch penetration will require 2 gallons per square yard. The top 2½ inches, which consists of No. 1 trap rock or its equivalent, is usually rolled, in order to get the utmost mechanical bond before the asphalt is sprayed into it, and additional rolling is done after the penetration, which is covered with pea stone, and again after the seal coat, which is covered with pea stone. The final, or backrolling, on a penetration road is exceedingly important, an item which is many times neglected. Consequently specifications require that a roller, in doing backrolling with the weather conditions favorable, shall not be allowed to backroll more than 1,000 lineal feet per day, spending one-half day on one length of 500 feet, and spending the other half day on the next 500 feet.

Bituminous macadam, as noted above, is usually laid on primary and secondary State highway routes, and on primary State aid roads, where the truck travel is not the greatest item. Where there is a large amount of salvage in an old road, this salvage many times can be used to advantage, where bituminous macadam or bituminous concrete is laid on top of such a pavement, whereas the salvage would be wasted if cement concrete was used.

In mountainous or hilly country the bituminous macadam is a very desirable pavement due to the fact that it provides a non-skid surface, comparatively safe in all kinds of weather.

The experience in Massachusetts on Federal aid highways, all of which have been built during the last ten or twelve years, indicates that the maintenance for the first five, and possibly the first ten, years of the life of a pavement has been less on a bituminous road than on a cement concrete road. This is borne out by maintenance cost data on the Newburyport Turnpike, where large sections of cement concrete and bituminous macadam were built in 1922 and 1923. It is also borne out by the maintenance cost data collected each year on Federal aid highways in Massachusetts.

BITUMINOUS CONCRETE PAVEMENT

The bituminous concrete pavement as built in Massachusetts is used for the most part in Plymouth and Barnstable counties, spoken of as the Cape Cod district, and on the islands of Marthas Vineyard and Nantucket. This is specified where the truck travel is not too heavy. It is the most economical pavement to build, as the natural materials are used as far as possible, — its cost running approximately $20,000 per mile for a 20-foot width. This pavement will carry a very large volume of pleasure vehicles, but it is not suitable for any large volume of heavy trucking.

The bituminous concrete type of pavement, as laid in Massachusetts, consists mostly of the sand asphalt type. This is not as high grade as sheet asphalt or Topeka, and for that reason the cost is considerably less. This pavement is laid, using the best available sand, and adding 30 per cent of stone screenings, and sometimes more stone screenings, in order to get a definite, composite mix. On the Provincetown project built in 1929, 50 to 60 per cent of stone screenings were added to the sand in order to make the combined mixture satisfactory, because the sand grains in the Provincetown area were all quite uniformly of one size. The bituminous concrete pavement on the Cape was usually built by bringing the natural subsoil to proper grade, hardening the surface, if it consisted of sand, with a material of clay or loam, and then laying a 2-inch course of bituminous concrete, which was thoroughly rolled and compacted. There was then added to this a second 2-inch layer, which was thoroughly rolled and sealed with about ¼ gallon of 85 per cent oil and covered with sand. These Cape roads are entirely suitable for pleasure travel, and if carefully built make a very smooth riding surface. They are, however, not suitable for heavy trucking, because during the hot weather a heavy truck standing on the pavement will displace the bituminous concrete, causing the wheels of the heavy truck to settle into the pavement.

Experiments have been conducted with this bituminous concrete by adding a filler of lime dust in order to make the pavement more stable. It has been found that from 5 to 10 per cent of a lime dust filler will materially increase the stability of the pavement.

A second type of bituminous concrete which is occasionally used, although not in the easterly portions of the Cape district, is the crushed gravel-asphalt mix. This is made by crushing bank gravel, taking the material that will pass 1-inch or ¾-inch screen, heating it and mixing it with the proper amount of asphalt. This gives a more stable mixture and more stable pavement than the sand asphalt mix, but as a rule this costs more money, and it is specified only where suitable natural bank gravel is available.

Detours during Construction

The construction process in highway building is economically carried on during the warmer seasons of the year. This is, of course, coincident with the periods when travel is greatest. All State highway projects of construction and reconstruction are prepared with definite consideration for the routing of traffic during such work, and suitable detour routes are designated and put in acceptable condition. The ideal method from the standpoint of construction costs is the complete exclusion of all traffic, a condition which is not always practicable, due to the necessity for local use of a road. In such cases, one-way traffic may be permitted, or traffic in both directions, at alternate intervals, under the direction of a special officer. The public is frequently impatient with even brief delays, but the safety of the public is a prime

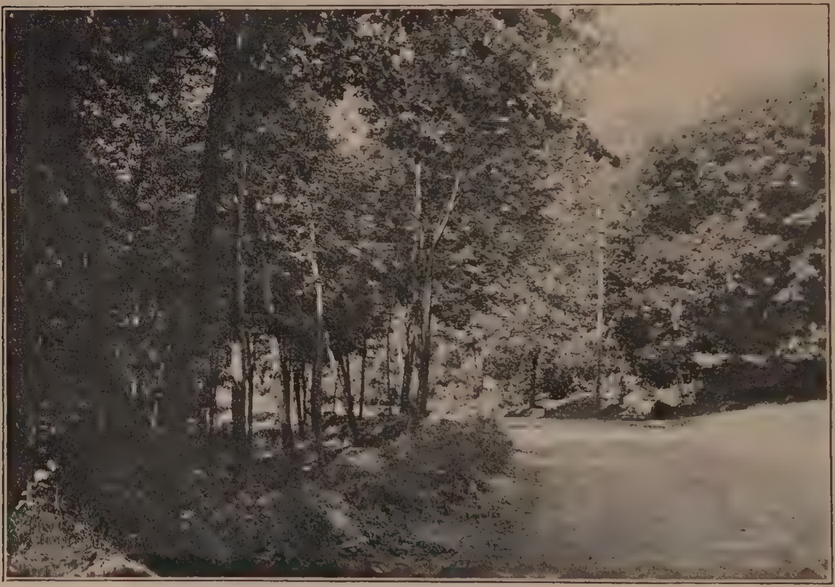

Fig. 11. — Safety Measure at Curves

Traffic line and visibility improved by trimming out undergrowth consideration during the road-building work. One notable example of complete exclusion of traffic is that during the recent reconstruction of the portion of the Mohawk Trail from Charlemont to North Adams, for a distance of about 16 miles, where blasting and the other phases of the work would be not only dangerous for traffic but extremely annoying, and because the ultimate advantage of the public would be greater by this more expeditious handling of the work, completing it within one season, rather than being subject to inconvenience for two seasons.

The careful layout of the detour, with direction signs, reflector signs and route numbers for night driving, was of great help.

Each month during the construction season the Department issues a route map indicating all construction work and describing travel conditions, — whether traffic will be permitted through the work or whether detours are necessary.

Super-Highways

Traffic volume increases are developing so rapidly that at some points congestion of traffic on the roads is of consequence, particularly in and near the municipal centers. Some of this trouble, extremely annoying to the motorists, is caused by the actual physical layout of streets, which may be constricted and therefore insufficient. Some of the difficulty, however, is capable of correction by the intelligent and logical control and direction of traffic in these particular centers. A number of instances of such conditions have been greatly improved by the local authorities after a study of the situation jointly with the Department, the measures bringing relief, including the prohibition of parking in certain areas and the re-routing of traffic movements.

This traffic condition creates a demand for wider highways, and suggests the construction of so-called "super-highways" designed for high speed and great volumes of traffic.

Massachusetts has been among the leaders in the adoption of wider pavements. It is believed that this State first changed the standard width of 15 feet to 18 feet, then to 20 feet and more recently to 24 feet, for State highways, and most recently this State has been building 30 and 40 foot pavements.

In 1926 and 1927 this Department built, on U. S. Route 3-A, in the towns of Hingham and Weymouth, 3½ miles of bituminous macadam, 40 feet wide, marked by white lines for four lanes of traffic. This road connects Boston and Quincy with Nantasket Beach and the summer resorts of the South Shore. This road is one of the most used State highways.

In 1928 and 1929 the State reconstructed and widened the Newburyport Turnpike, U. S. Route 1, for a distance of 18 miles, providing a 30-foot pavement marked for three lanes of traffic. This highway leads from Boston toward New Hampshire and Maine. The remaining seven miles will be reconstructed at an early date.

The Southern Artery, so called, in Boston and Quincy, on Route 3-A, built in 1926 and 1927, includes five miles of bituminous macadam pavement 40 feet wide, designed for four lanes of traffic, except for one-half mile designed for three lanes of traffic. This highway serves as an artery for traffic between Boston and the cities and towns of southeastern Massachusetts. It also serves as a by-pass, avoiding the centers of Milton and Quincy.

Another project in Cambridge, the Alewife Brook Parkway extension, is being built with a 40-foot bituminous macadam pavement, for a distance of 1.7 miles.

By-Pass Routes

The by-passing of congested centers on the important through routes is a matter which has been given consideration by the Department. Their advantages for through traffic are evident, and in some cases there is benefit to the locality by the reduction of congestion to traffic which normally may be largely local. Some communities have opposed by-pass routing, in the belief that the deflection of traffic would result in a certain business loss. Other communities have, however, been agreeably satisfied by the resulting relatively quieter local traffic conditions.

The Department does not in general favor long by-pass routes as such. The distinction between a by-pass route and an alternate or parallel route may be one of definition, as, for example, the proposed route from Worcester to Boston along the route of the old Worcester Turnpike.

State Highway Grade Crossing Eliminations on Through Routes

For a number of years the Department has made it a policy to eliminate grade crossings and dangerous underpasses from the through routes as rapidly as possible in its program of construction and reconstruction of State highways. Some of these projects have been accomplished by constructing bridges, but more generally by the absolute elimination of such hazardous points through the construction of by-passes on entirely new highway locations.

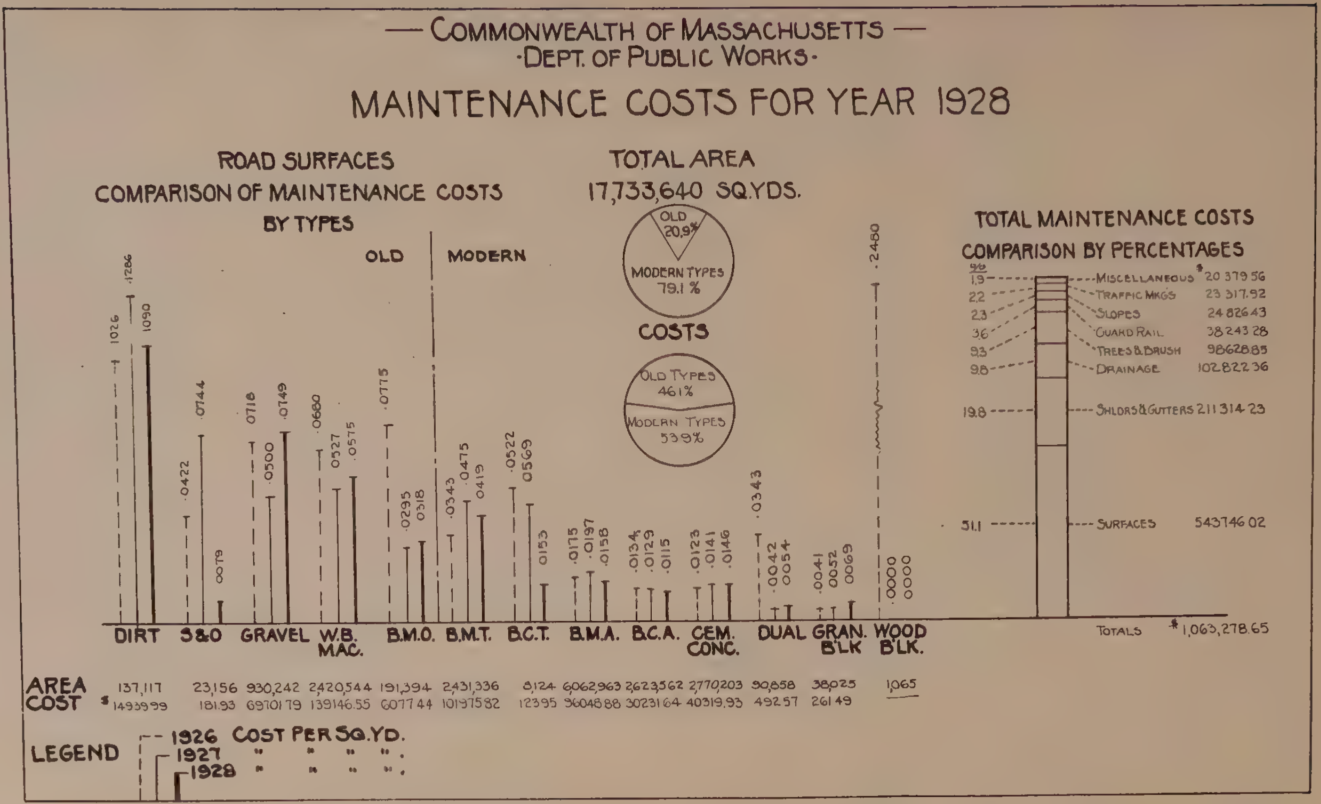

FIG. 12. — SURFACE MAINTENANCE COSTS, PER SQUARE YARD, FOR YEAR 1928

Notable examples of such projects are the following: In 1924, in Dighton, on the Boston–Fall River route, two grade crossings were eliminated by the construction of a by-pass.

At Wareham, during 1924–25, one grade crossing, one overhead bridge and an underpass were eliminated by a highway built on a new location, thus completely eliminating dangerous features on the old road.

At Falmouth, from Buzzards Bay to Woods Hole, one underpass and two overhead bridges were eliminated by a by-pass location.

At Wilbraham the dangerous underpass under the Boston & Albany Railroad has been reconstructed, now providing safer approaches.

At West Springfield, on Route 20, two underpasses were eliminated in 1927.

In Deerfield, in 1928, one underpass and one overhead bridge have been eliminated by the complete relocation of the State highway in that vicinity.

In Lanesborough, on the Pittsfield–North Adams Road, one grade crossing and one overhead bridge have recently been eliminated.

The present construction of the extension of the Alewife Brook Parkway includes the erection of two heavy truss bridges carrying the new parkway over the tracks of the Boston & Maine Railroad.

Maintenance of State Highways

The law relating to State highways (chapter 81, General Laws) places the responsibility for their control and maintenance in the Department of Public Works. The physical maintenance of surface is supplemented by the performance of other work fully as necessary for the safe operation of the highways and for the most efficient and gratifying use of this facility provided by the State. Such work includes the prevention of encroachment upon the layout by any private structures without the consent of the Department, the neat and orderly appearance of the roadsides, the erection of traffic, warning, control and direction signs and signals and the placing of symbols on road surfaces, and the removal of snow from the important, selected highway routes during the winter.

Many of these duties have been placed upon the Department by various laws which have resulted from the logical necessity and wisdom of such provisions. This work is carried out as noted above under the direction of the Maintenance Engineer, who directs this work through a permanent maintenance organization in each district in charge of a maintenance foreman, the numbers varying upwards to a maximum of sixty men per district in the summer season.

Safety, of course, is one of the prime objectives of the maintenance work, followed by the consideration of utility and sightliness.

All surfaces, therefore, are kept in a safe condition by constant inspection, and locating points where repairs are necessary, and early attention is given to incipient breaks or to any indication of disintegration.

Maintenance of Older Type Surfaces

The older types of surface, namely, the waterbound macadam and gravel, are given surface treatments of ⅕ gallon per square yard of hot asphaltic oil or of tar as required, generally once in from two to five years. Careful paint patching with the same material, from time to time, generally prevents the formation of any holes.

The last of the dirt surface type of State highway has been wholly reconstructed and replaced by bituminous macadam during the last two years. This is on the Mohawk Trail.

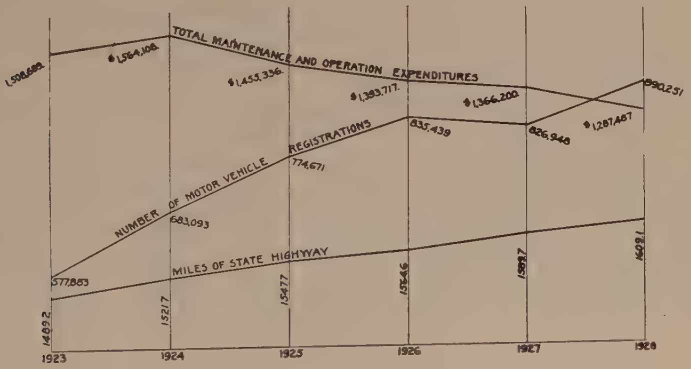

FIG. 13. — COMPARISON OF YEARLY EXPENDITURES FOR MAINTENANCE OF STATE HIGHWAYS

Six-year period, 1923–1928

Maintenance of Modern Type Surfaces

The more modern types of surfaces, such as bituminous concrete, bituminous macadam and cement concrete, require more individual care.

Maintenance of Bituminous Concrete. — Bituminous concrete of the usual high type requires but little attention. If holes do develop it is generally because of subgrade failure, in which case the defect is corrected and the surface restored.

The type of bituminous concrete constructed on Cape Cod is rarely in need of surface treatment, but it is essential that the seal coat be kept intact. This is done by paint patching as required. When such a surface is in need of an application of bituminous material, hot asphaltic oil is used at the rate of ⅕ gallon per square yard and heavily sanded.

Maintenance of Bituminous Macadam. — A bituminous macadam surface of trap rock, penetrated with a good grade of bituminous material, laid on a well-drained roadbed of proper width and thickness, requires practically no maintenance. Some of the older bituminous macadams, however, contain a large percentage of local stone, which is soft, and furthermore, they are not thick enough, or are over subgrades that are not well drained.

Surfaces composed of local stone fail because of the disintegration of the individual stones, thus permitting the entrance of water and frost that will eventually disrupt the entire surface. This condition is easily discerned, however, and corrected with a seal coat of either hot asphaltic oil or penetration asphalt.

Defects caused by lack of strength, due to insufficient thickness, and by subgrade failures are corrected by scarifying the old surface, adding fresh stone to obtain the required strength and thickness, rolling, binding with sand or stone screenings, and establishing a bituminous pavement by the application of two treatments of cold tar (⅜ gallon per square yard) with the sanding and rolling of each application. The following year a heavier bodied asphaltic oil is applied. Some work has been done using asphalt emulsion to penetrate a surface that has been scarified and shaped, adding fresh stone as required, and rolled. The results are satisfactory, and there is little question but that the use of asphalt emulsion to penetrate a scarified surface will become more general.

Maintenance of Cement Concrete. — While cement concrete surfaces, on the whole, require but little maintenance, that little is hard to give. Joints and cracks are kept filled, being poured twice a year, in the spring and again in the fall. Asphalts and tars are each used for this. Surfaces which have scaled are paint patched, using a bituminous patching compound, or 85 per cent asphaltic oil, and sanded. Surfaces which are disintegrating too extensively, or have become too unsightly because of the number of cracks and bituminous patches, are given a surface application of ⅕ gallon per square yard of 85 per cent asphaltic oil or hot light tar and covered with a mixture of stone chips and sand. During the past season considerable use has been made of asphalt emulsion for the surface treatment of cement concrete surfaces. The emulsion is applied at the rate of ⅓ gallon per square yard from an air pressure distributor, and covered, first with ⅜-inch stone chips and then with a well-graded sand. The presence of water in the emulsion delays the setting up long enough to permit of maximum penetration by the mineral aggregate. Applying the sand before the chips assures of full penetration of the chips. It is considered essential to use sand with the chips in order to form a matrix that will more positively hold the chips in place.

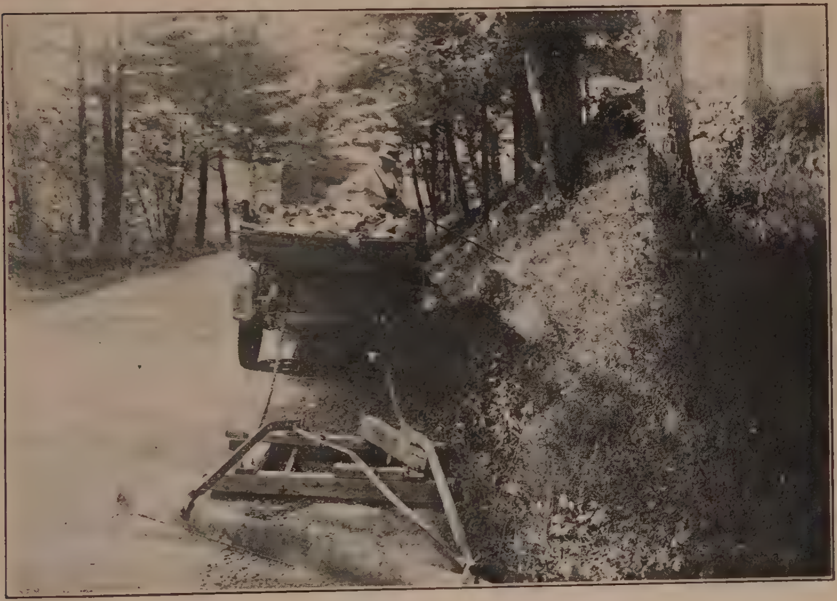

Fig. 14. — Maintenance of State Highways

Dragging shoulders and cleaning roadside simultaneously

Other Features of Maintenance Work

The shoulders adjacent to all types of surfaces must be kept in such condition that they will not only make possible the proper disposal of surface water, but shall be safe at all times. In the spring gravel is added when the shoulders are low, and those which are higher than the surface are scraped with a road machine. During the rest of the season they are kept in condition by dragging once or twice a week. It is found that such maintenance likewise protects the edge of the macadam and bituminous concrete surfaces. It is interesting to note that the care and upkeep afforded the shoulders of cement concrete surfaces costs almost as much as the care and repair of the surface itself.

Catch basins, culverts, ditches, etc., are cleaned out during the fall and as often during other periods of the year as required. Additional drainage systems are frequently installed to provide outlets where water gathers. Side drains are installed wherever subgrade defects are corrected.

All guard rail, both the old wooden type and the new cable type with cement concrete posts, is painted at least once in two years, repaired promptly when broken, and kept at all times in a presentable condition.

The care given to the roadsides has come to have a larger significance than was the case a few years ago. Today, not only are the roadsides mowed, but they are mowed with intelligent care, in order that sightly clumps of flowering and other shrubs may be spared to add to the beauty that the Department is endeavoring to develop in the roadsides. An effort is being made to properly care for all existing trees and shrubs, and to plant others where needed; to open up vistas by judicious trimming, and to make the entire layout clean, sightly and beautiful. The major part of the work, such as the trimming of grass, weeds and brush, the removal of dead limbs and trees and the routine planting, is done by the maintenance forces of the districts. The work as a whole is under the direction of a Highway Landscape Supervisor. Connected with this work there are three nurseries which contain all types of trees and shrubs that are considered suitable for planting on the roadsides of Massachusetts. For carrying out this work there is a corps of trained men, who perform all the work of a more scientific nature in tree repair and surgery, and in the carrying out of the planting program.

Snow Removal

This Department is empowered by the Legislature to remove snow from State highways on routes which it considers of sufficient importance, at the expense of the Commonwealth, and to assist towns in their work of removing snow from town roads constituting parts of these same routes. During the present year, 1929–30 season, the Department has selected for snow removal 1,366 miles of State highway and 99 miles of town highways. Cities and towns will clear also 350 miles of their roads on the routes approved by the Department, so that in all, about 1,815 miles on through routes will be kept open for travel. This does not include mileage otherwise locally cleared. This Department controls 102 trucks, nearly all of which are equipped with blade plows, which are used for patrol work, and hires as many more trucks as may be required. All trucks work in tandem, starting with the storm. Twenty-three 5 and 10 ton tractors equipped with "V" plows are stationed at central points, and used in emergencies, and to widen if required. During the present year one of the larger trucks will be equipped with a rotary plow and three will be equipped with "V" plows with wings. It has come to be considered essential in this State that the snow be removed as promptly as possible, not only to keep the roads open, but to prevent as far as possible the formation of any ice from snow that has been packed down by passing machines. Sand piles mixed with calcium chloride are located at convenient places along the roadside and all icy areas that may develop on the highways are sanded as promptly as possible. Special attention is given to curves, hills and intersections. Seven mechanical spreaders are now used to supplement the hand labor, and it is probable that more spreaders will be purchased. All snow removal equipment is stored and repaired during the summer months at the central shop and garage in Boston, and such equipment is used for no other purpose than to remove snow.

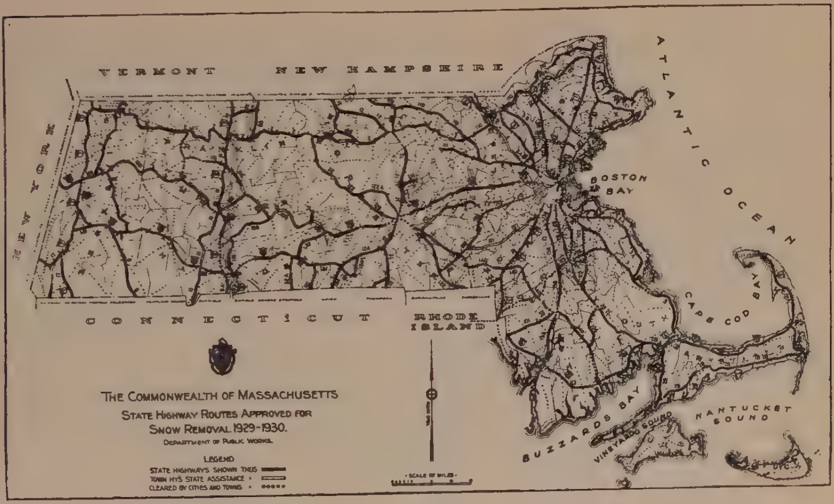
VERMONT
NEW HAMPSHIRE
NEW YORK
BOSTON BAY
ATLANTIC OCEAN
CAPE COD BAY
CONNECTICUT
RHODE ISLAND
THE COMMONWEALTH OF MASSACHUSETTS
STATE HIGHWAY ROUTES APPROVED FOR
SNOW REMOVAL 1929-1930.
DEPARTMENT OF PUBLIC WORKS.
LEGEND
STATE HIGHWAYS SHOWN THUS
TOWN HY'S STATE ASSISTANCE
CLEARED BY CITIES AND TOWNS
SCALE OF MILES
BUZZARDS BAY
VINEYARD SOUND
NANTUCKET SOUND

FIG. 15. — SNOW REMOVAL–ROUTES TO BE CLEARED BY STATE

UNIFORM TRAFFIC SIGNS AND SIGNALS

As a further development of the functions of the Department relating to highways, chapter 357, Acts of 1928, provided that the Department is required to erect and maintain on State highways and on ways leading thereto, and on all main highways between cities and towns, direction signs, warning signs or lights, curb, street or other traffic markings, mechanical traffic signal systems and similar devices for promoting the public safety and convenience. No other authority is permitted to erect any such signals or signs without the approval of the Department. No rule, regulation, order, ordinance or by-law of a city or town hereafter made or promulgated, relative to or in connection with such signs, signal systems or devices, shall take effect until approved in writing by the Department. The purpose of this is to establish uniformity throughout the State in the use of such signs, signals and systems.

This act also provided for the establishment of through ways by the Department, whether on State or other highways, and, with the approval of the Department, cities and towns may also designate such ways.

In pursuance of this authority the Department has conducted studies relative to traffic control on highways within the Commonwealth, and it has formulated principles of great advantage to the cities and towns in their plans for traffic control, a matter which by law is their function. The Department's written approval of all traffic control signals is necessary before these become legally operative.

Traffic Code

Massachusetts may take considerable pride in the fact that it is the first State officially to provide for uniformity in traffic devices. A "Standard Signal Code" has been adopted to meet the spirit as well as the letter of this provision. The requirements of the code are moderate and in accord with generally accepted national standards.

The code has been designed to conform to national standards, but adapted to the peculiar conditions existing in New England, and therefore it may point the way toward regional uniformity.

Traffic Rules and Regulations for State Highways

As a further definite step in promoting the most efficient use and operation of State highways, and for the control of traffic, which is important from the standpoint of making the highways safer, the Department has issued rules and regulations for traffic on all State highways, and these rules have been approved by the Governor and Council, becoming effective on November 1, 1929.

SIGNS AND SIGNALS ERECTED BY THE DEPARTMENT

The standards prepared by the Association of State Highway Officials governing the design and display of warning, directional and informational signs have been adopted by the Department. All State highways are now posted with signs conforming to these standards. Likewise, the national automobile routes laid out by the Joint Board on Interstate Highways have been posted with the standard United States shield bearing the number of the route. In addition, all other routes of importance have been given State route numbers, which are posted with a square marker, bearing black numbers on a white background. Many route markers are made of pressed steel and equipped with headlight reflecting bull's-eyes, which render the information and directions as effective at night as during the day. The route numbers, used to guide motorists along the route, are supplemented at ambiguous

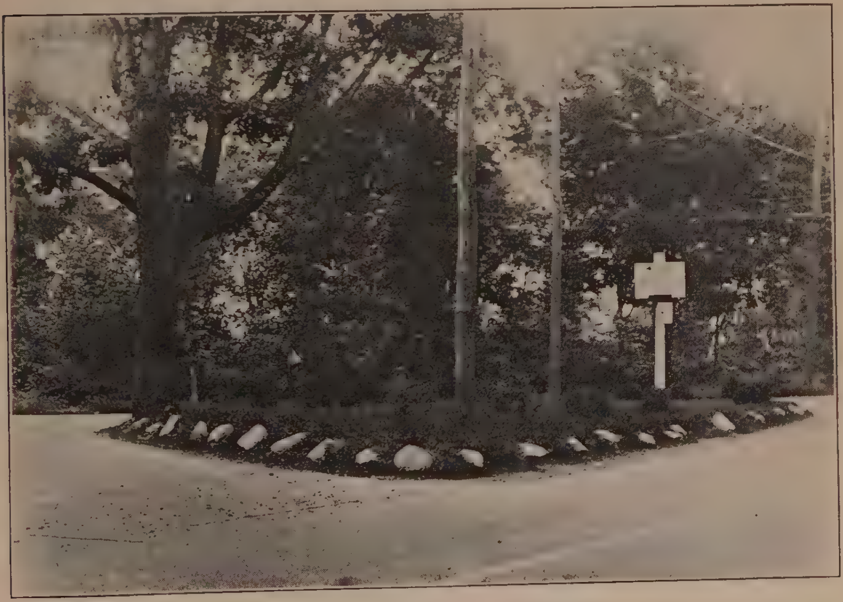

FIG. 16. — ROUTE MARKING

Direction sign and traffic lines at route intersection turns, wide intersections and at other points by large direction signs mounted on concrete posts. These signs show, in addition to the route number and an arrow, the names of the four towns ahead, thus defining the route, with the mileage to each. All signs, both warning and directional, are of No. 8 gauge steel subjected to a rustproofing process. These are assembled, lacquered and lettered in the shop operated by the Department.

All data for the location of signs are collected by one engineer from the main office, who likewise supervises the preparation and erection of the signs, using the district forces for the latter purpose. In this way uniformity in the application of the theory governing the location of signs is assured.

Highway Maintenance Shop

The Department operates a shop and garage in Boston where all equipment not assigned to the districts for their ordinary maintenance work is stored. While the term "garage" is used, it is not such in the sense of being a repair shop, because the Department instituted the policy some few years ago of having all equipment repaired and overhauled by the nearest service station of the company from whom the equipment was purchased. A distinct improvement in the condition of the equipment has been achieved, and the system has likewise been most economical. The equipment consists of steam rollers, snow removal trucks, air compressors, etc., all of which is assigned to the districts for use during the season and is called in when the work is done. Each piece of equipment is then inspected, necessary work determined, and the truck or roller, as the case may be, turned over to the service station. A State inspector is kept on the work at all times.

All plows, both blade and tractor "V" plows, are dismantled, repaired, painted, reassembled and put back on the equipment. By the middle of October all snow removal equipment is ready to move.

An important activity at the shop is the assembling and making of traffic signs for State highways. The shop is fully equipped with spray booths, lettering department and monorail carrier for routing signs through the shop, and is built of up-to-date fireproof construction. These highway signs are sent to the assigned location on trucks having bodies specially designed for the purpose. Direction signs are erected on cement concrete posts, 6 inches thick and 6 feet 6 inches in height. These posts and all highway bounds used to mark the limits of State highway layout are constructed at the shop. All paint used on State highways and bridges is also mixed at this shop.

HIGHWAY TESTING LABORATORY

The Department maintains a testing laboratory for the testing of materials purchased for maintenance of highways and for studies of construction processes and results as determined by test upon samples taken from the completed work. This laboratory is helpful in maintaining control of the processes in the highway work and in formulating new processes and methods.

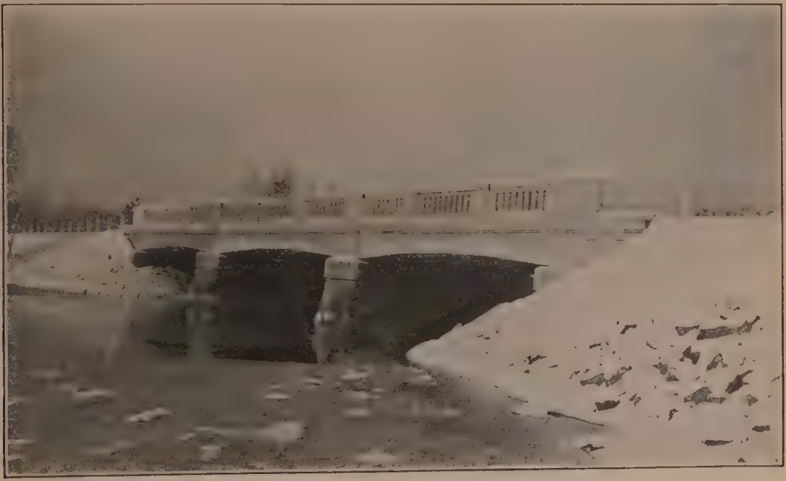

FIG. 17. — BRIDGE ON STATE HIGHWAY CROSSING POWOW RIVER IN AMESBURY

Reinforced concrete beam and slab, built in 1928

BRIDGES ON STATE AND OTHER HIGHWAYS

For many years following its establishment in 1893, the Massachusetts Highway Commission did very little bridge work with the limited funds at its disposal, because it was deemed a better policy to construct as many miles of highway as possible. Only such bridges as were absolutely required were constructed. Generally, when roads were laid out and constructed as State highways, the bridges were not included as part of the State highways. As a result, many of the bridges on our State highway routes remained under the control of the local town or city authorities and received only a half-hearted maintenance. The seriousness of this situation was not apparent until the use of heavy motor trucks as a means of freight transportation made it evident that bridges which might serve for pleasure traffic and the ordinary loads of the horse-drawn vehicle were totally inadequate for the heavy loads carried by the motor trucks.

As soon as this fact was recognized, the Department started a program of bridge construction which would place its bridges on a par with its improved highways. This increased attention to bridges began about 1920, and, although the amount expended has increased steadily, the end is not yet in sight. As indicating the increasing amount of bridge work it is interesting to note that in 1922 about $400,000 was expended for bridges alone, and even this amount is small when compared with the $1,100,000 which the Department is spending for bridges this year.

In expanding this work of the Department, a bridge section was established as a distinct unit in the late fall of 1920. Previous to this time all bridge work was done in connection with the regular highway work. The original bridge section consisted of a Bridge Engineer and three or four assistants. A constantly increasing amount of this work has caused a steady growth in this section, until today there are fourteen designers and draftsmen under the direction of the Bridge Engineer. The field supervision of bridges is handled largely by resident engineers assigned by the District Highway Engineers in connection with the highway construction. There are, however, five resident engineers engaged solely in bridge construction most of the year.

Approval of Bridges on Public Ways

The design and the supervision of construction of all bridges on State highways, while comprising the major part, does not represent all of the work performed by the bridge section. Under a State law it is possible for a city or town to bring its bridge problems to this Department. Such requests for advice may require merely an examination and a report on the condition of an existing structure, together with recommendations for its improvement. More frequently, however, examination indicates that a new structure is required, for which complete plans and specifications may be prepared and the construction supervised, if our force is sufficient to take care of the work. The law also requires that plans and specifications for all bridges over ten feet in span, which are to be erected on any public way, by any party other than the State, shall be submitted to this Department for approval unless specifically exempted by statute.

Bridges financed jointly by the State and the towns and counties, or by the State and public service corporations, are usually designed and the work carried out by this Department. It is called upon, frequently, to make engineering investigations for other State departments; to prepare estimates and reports for the Legislature; and to make studies of contemplated projects.

Standards of Bridge Design

In the design, each proposed bridge is studied as an individual problem, but certain materials and types have been adopted as standard construction. This State was the pioneer in this country in the use of reinforced concrete for bridges, and still continues its use wherever practicable. Experience has shown that reinforced concrete bridges may be considered as relatively "permanent" structures. For single spans, too great for the economical use of reinforced concrete, or in locations where the use of multiple concrete spans is prohibited by the requirements of clear waterway, steel is used. Wood is used very little as a bridge material, it being the policy of this Department to build more permanent structures.

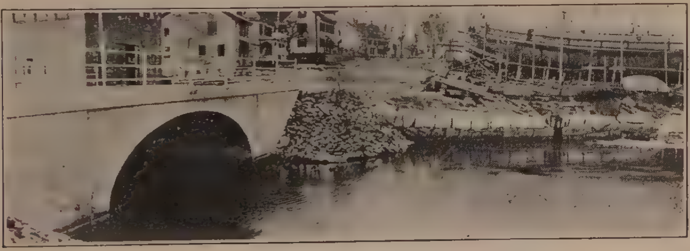

FIG. 18. — BRIDGE ON STATE HIGHWAY CROSSING ESSEX RIVER IN ESSEX

First concrete arch bridge built by Massachusetts Highway Commission, 1902

State Highway Bridge Designs

All State highway bridges are designed for a 20-ton loading. The standard width of roadways is 40 feet for primary routes and 30 feet for the less important highways. The increasing number of accidents on bridges has led to an increase in the height of the curbs, 10 inches being the minimum. All concrete bridges over 20 feet in span have heavy concrete fences, and a substantial metal fence is used on through steel spans.

Future Bridge Problems and Financing

About a year ago a very complete investigation was made of bridges over 20 feet in span in this State. The full report, which may be found in Senate Document No. 10, January, 1929, is too lengthy to be included in a paper of this sort, but a brief synopsis may be of interest as showing present conditions and future needs. There are about 4,100 bridges and 1,700 railroad grade crossings, located on the highways in this State. Many of these bridges and railroad grade crossings are located on highways of only local importance. Eliminating such structures, it is found that there are 716 bridges and 196 railroad grade crossings located on the main through routes of travel. By "through routes" is meant that system of highways connecting practically every one of the 355 cities and towns of this State.

Of these 716 bridges, 187 are controlled by the State, 290 are under other public control, and the remainder, consisting of highway bridges over railroads and railroad bridges over highways, are controlled by the various railroads, although the surface in many instances is maintained by the local authorities.

Many of these bridges were constructed before the advent of the heavy motor trucks, and it is safe to say that with the exception of the masonry arches they are being heavily overstressed by the loads of today. Furthermore, many structures while of sufficient strength are of inadequate width, or improperly located, safely to provide for today's traffic needs.

The problem is primarily one of the maintenance and reconstruction of existing bridges. Except for new structures made necessary by an original separation of railroad and highway grades, very few bridges are built on new locations.

It has been estimated that in the next twenty years approximately $43,600,000 will be required for the maintenance and necessary reconstruction of existing bridges and underpasses on the through routes. This sum is divided as follows:

187 bridges under State control	$2,100,000
290 bridges under other public control	25,630,000
Reconstruction of 102 of the 127 bridges over railroads	9,140,000
Reconstruction of 57 of the 107 underpasses	6,730,000
	$43,600,000

It should be noted that the first two items, amounting to $27,730,000, must be met wholly from public funds, while the two other items amounting to $15,855,000 are paid jointly by the railroads and public funds, the exact division being usually fixed by a decree of the courts.

In addition to this, it has been estimated that it will cost about $19,000,000, exclusive of property damage, to abolish the 196 railroad grade crossings on the through routes.

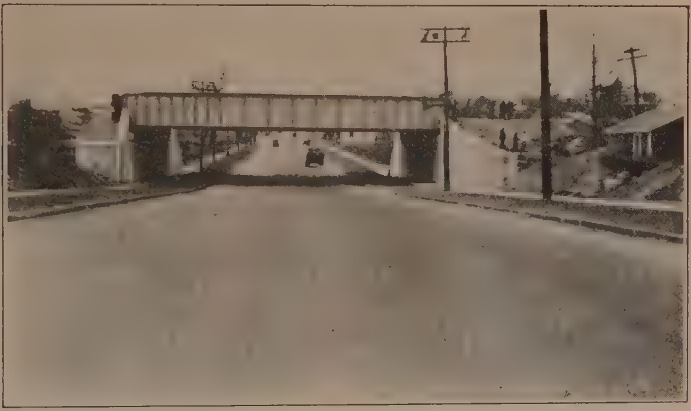

Fig. 19. — Bridge over Southern Artery, Boston, carrying Tracks of Boston Elevated Railroad over Codman Street

Largest plate girder erected by Department; span, 85 feet c. to c. of bearing; web plate, 120 inches

While bridges and grade crossings on through routes of travel are of paramount importance and entitled to first consideration, they comprise only 15 per cent of the total bridges and grade crossings in this State.

Included in the other 85 per cent of these bridges and crossings located on the less important highways there are 1,464 grade crossings, 2,200 bridges over streams, 653 bridges over railroads, and 439 underpasses or railroad bridges over highways. Although the data regarding this group of bridges and grade crossings is somewhat incomplete, estimates indicate that approximately $56,000,000 may be required for the maintenance and necessary reconstruction in the next twenty years.

EARLY FINANCING OF STATE HIGHWAYS

Bond Issues

The act creating the Massachusetts Highway Commission required that an appropriation should be made by the Legislature before any construction could be undertaken, which made it impossible to begin any road building during the first year. This defect, however, was corrected by an act passed the following year, accompanied by an appropriation, so that the Commission then became possessed of means to enable it to accomplish some substantial work, and during the latter part of August, 1894, the actual construction of roads was begun.

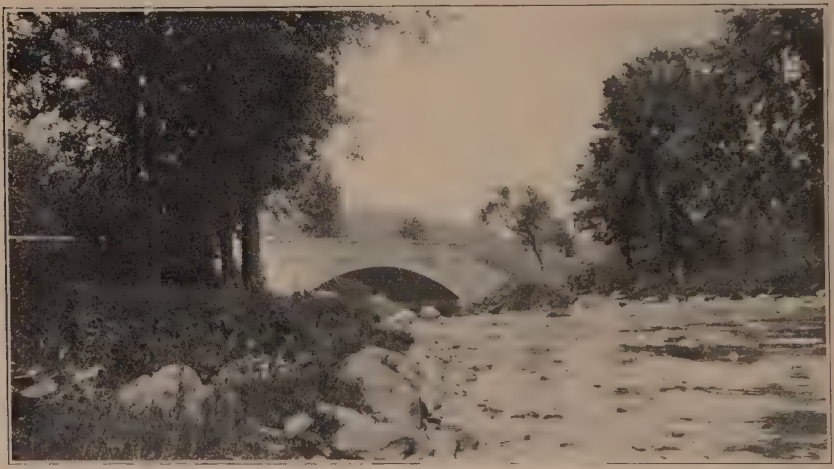

FIG. 20. — BRIDGE ON STATE HIGHWAY CROSSING WESTFIELD RIVER, CUMMINGTON

Reinforced concrete arch

The first appropriation amounted to $300,000 for the construction of State highways. This money was raised by the issuance of sinking fund bonds maturing in twenty-six years, bearing interest at 3½ per cent. During the first ten years, ending with 1903, a total of $4,525,000 of sinking fund bonds were issued, an average of about $450,000 per year. Their terms varied from twenty-five to thirty years.

Beginning with the year 1904, the State issued only serial bonds for State highway construction, rather than sinking fund bonds. During the period 1904 to 1916, when the last bonds for State highways were authorized, a total of $7,242,000 serial bonds had been issued. The gross amount of bonds issued for State highways, therefore, was $11,767,000.

In addition, there was authorized for the improvement of the roads in the towns of the five western counties, in accordance with the provisions of chapter 221, Acts of 1915, $2,000,000 in serial bonds covering a period from 1915 to 1918, inclusive.

At the present time many of the roads improved under the act of 1915 have been laid out as State highways.

The repayments on sinking fund and serial bond issues have been made annually, so that at the end of the fiscal year 1928 there were only $2,850,520 in bonds outstanding.

ASSESSMENTS ON COUNTIES, CITIES AND TOWNS FOR STATE HIGHWAYS

When the State highway law was passed it provided that one-fourth of the cost of construction and maintenance of State highways should be assessed upon the various counties, and the money so received by the State was made available for further construction by the Commission.

In 1913 the law was amended so that the municipalities in which the maintenance work on State highways was done should repay to the Commonwealth a portion of such cost, not exceeding in any case 50 per cent of the cost; in towns of less than $1,000,000 valuation, not over $50 per mile of State highway; in towns whose valuation is between $1,000,000 and $2,000,000, $100 per mile; in towns whose valuation is between $2,000,000 and $5,000,000, not over $200 per mile; and in cities and towns over $5,000,000 valuation, not exceeding $2,000 per mile in the aggregate and not over $500 in any one year, the balance to be assessed in the three succeeding years.

MOTOR VEHICLE FEES

Registration of motor vehicles became part of the work of the Highway Commission as provided for by an act passed in 1903. In that year the receipts were $17,684. Motor vehicle fees and fines became available for expenditure by the Highway Commission in 1908, when the receipts, including fines, amounted to $147,637.35 for that year. In 1919, when the last bonds were issued for State highways, these motor vehicle receipts amounted to $2,736,727.29. The rapid growth in receipts from such sources in Massachusetts is comparable to that in other sections of the country. In 1928 these receipts amounted to $13,919,618.24.

The Highway Fund

In order to prevent any encroachment on the funds available for highways the Legislature of 1925 established the so-called Highway Fund in the treasury. This law provided that the motor vehicle fees and fines, together with all contributions and assessments paid into the State treasury by cities, towns or counties for maintaining, repairing, improving and constructing ways, whether before or after the work is completed, and all refunds and rebates made on account of expenditures on ways by the Department of Public Works, shall be paid into the treasury of the Commonwealth and credited to a fund to be known as the Highway Fund. This law was amended in 1928, so that the receipts from the gasoline tax are also paid into this fund.

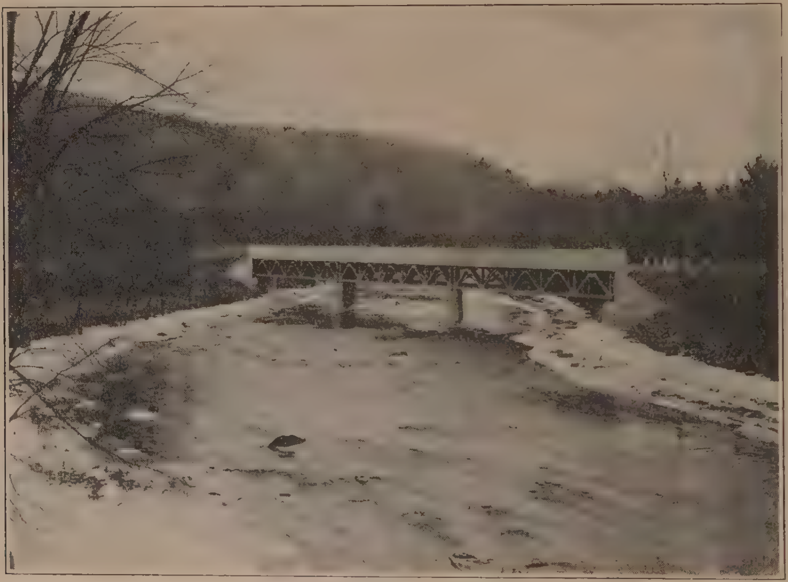

Fig. 21. — Bridge on State Highway crossing Westfield River in Huntington

Three-span deck steel truss, built in 1928

The disbursements from this fund are made annually by legislative appropriation and include the following:

1. The expense of the running of the Registry of Motor Vehicles and the cost of collecting the gasoline tax.

2. For expenditure under the direction of the Department for the following purposes:

(*a*) Maintaining, repairing, improving and constructing town and county highways, together with any money which any town or county may appropriate for such highways, which, however, remain town ways.

(*b*) Maintaining, repairing and improving State highways and bridges.

(*c*) Construction of State highways in addition to Federal aid payments.

(*d*) Engineering services, and expenses, care and purchase of road-building machinery, snow removal, erection and maintenance of direction and warning signs, care of trees and shrubs on State highways.

(*e*) Interest, sinking fund and serial bond payments on State highways and western county highways.

(*f*) To meet the Commonwealth's share of the interest, sinking fund and serial payments on Metropolitan Parks Loans (Series II), and to pay such sums as the Commonwealth may be required to pay out of receipts from motor vehicle fees for particular traffic routes that may be authorized.

3. For expenditure under the direction of the Metropolitan District Commission, to meet the Commonwealth's share of the cost of maintenance of boulevards in the Metropolitan Parks District and the Commonwealth's share (one-half) of the cost of construction of boulevards within this district now or hereafter authorized.

4. For expenditure under the direction of the Department of Public Safety, for the maintenance in part of the Division of State Police.

Federal Aid

Since March, 1917, when Massachusetts accepted the provisions of the Federal Aid Act, the amounts received from the Federal government have been held in the treasury of the Commonwealth as a trust fund for use by the Department, and are designated "Highway Trust, United States Grant." The total receipts from the Federal government to November 30, 1928, is $8,718,278.16.

Gasoline Tax

An act passed in 1928, in effect on January 1, 1929, provides for a tax of 2 cents a gallon on all gasoline consumed by motor vehicles upon the highways of the Commonwealth. The receipts from this tax are credited to the Highway Fund for appropriation as described above. The cost of collection in this State is only nominal, because the law provides that the tax shall be paid in the first instance by the general distributors.

EXPENDITURES

State Highways

The expenditures for State highways include the cost of construction, maintenance and repair, and reconstruction. From 1893 to the end of the fiscal year 1919, the final year of the former Massachusetts Highway Commission, there had been constructed 1,270 miles of State highways at a total expenditure, for construction alone, of $13,581,012.49. The maintenance and reconstruction costs during that same period amounted to $13,108,017.95. The sum of these two amounts, or $26,689,030.44, was spent during a period of twenty-six years.

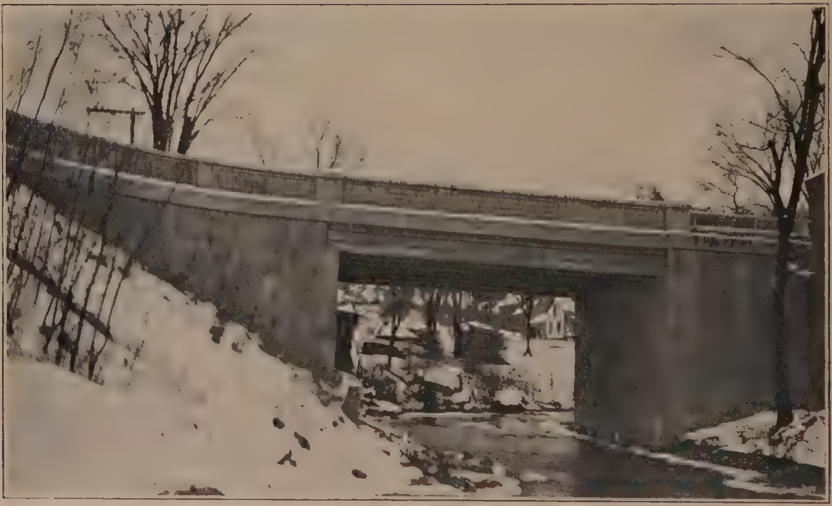

FIG. 22. — BRIDGE ON STATE HIGHWAY CROSSING SOUTH RIVER, CONWAY

Reinforced concrete beam, with curved wing wall approach

During the next nine years the extension of the State highways and the greater revenue received made possible great improvements.

At the end of the fiscal year, November 30, 1928, concluding a period of thirty-five years, the mileage of State highways, the construction of which was completed, amounted to 1,578 miles, and the total expenditures for construction to that date amounted to $33,325,390.42; the expenditures for maintenance and reconstruction of highways for the same period, amounted to a total of $51,231,346.16. The sum of these two figures, or $84,556,736.58, represents a very substantial investment on the part of the Commonwealth for State highways, the important through ways of the Commonwealth which benefit all the communities from one end of the State to the other.

State, County, Town Co-operative Work

In 1910 an act was passed authorizing the Highway Commission to spend 20 per cent of receipts from the motor vehicle fees and fines on "through routes" in co-operation with municipalities and county authorities. This work, done under the original act and its amendments, now designated as chapter 90, General Laws, has grown to be a very important part of the Department's work.

The roads improved are usually secondary routes, and after improvements are completed these roads remain town or city ways and must be properly maintained by the municipality in accordance with the agreement entered into between the State and the city or town. The amount expended from State funds, exclusive of contributions from counties and municipalities to 1919, was $1,793,829.66. The total State expenditure through 1928 amounted to $12,496,099.25.

Expenditures for Small Town Roads

In 1900 an act was passed directing that an amount equal to 5 per cent of the annual appropriation for the construction and repair of State highways be expended on highways in small towns where no State highway had been constructed, and that the amount to be expended in any one year in a town should not exceed 40 per cent of the amount of the town's average expenditure for a period of five years just preceding. The total amount spent under authority of that act and its amendments was $1,410,756.74 to 1910, when the act became ineffective after the passage of another act in that year enabling the Highway Commission to expend 20 per cent of the motor vehicle fees and fines on through routes in conjunction with towns and counties.

Maintenance of Ways in Small Towns

In 1918 an act, chapter 155, was passed authorizing the Highway Commission to make certain expenditures for general repair and improvement of public ways, other than State highways, in towns of less than $3,000,000 valuation in conjunction with certain amounts contributed by the towns. The law was amended so that the valuation limit is now $4,000,000. The total expended by the State from 1918 to November 30, 1928, is $5,535,383.77.

Highway Improvements Authorized by Special Acts

Highway improvements have in some cases been authorized by special act passed by the Legislature. During a period from about 1908 to 1928 a total expenditure of $3,835,229.89 has been made for this work.

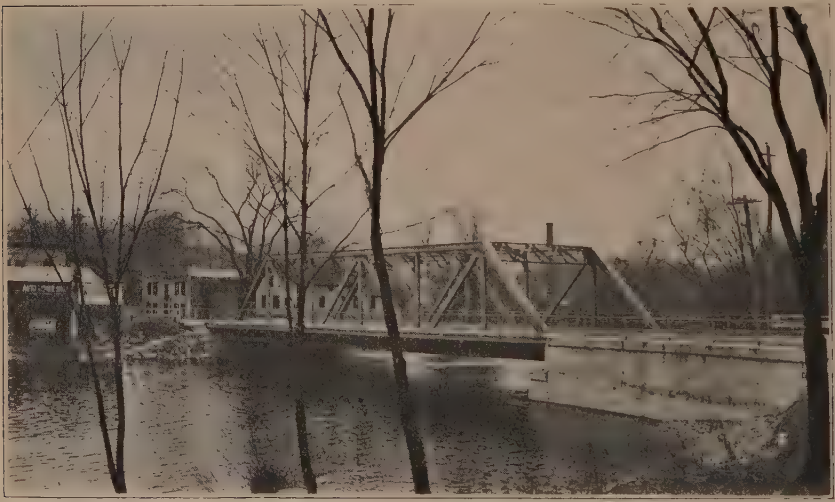

FIG. 23. — BRIDGE ON STATE HIGHWAY CROSSING HOOSATONIC RIVER IN LEE

Through truss, 120-foot span, 30-foot roadway, and two 5-foot sidewalks

Expenditures in Five Western Counties

The expenditures by the State for certain ways in the five western counties since 1915 amounts to $3,762,100.

State's Contribution for Metropolitan Parkways and Boulevards

Since the creation of the Metropolitan Park Commission, in 1894, the State has appropriated funds to co-operate with the thirty-eight cities and towns in that portion of the State surrounding Boston, designated as the Metropolitan Parks District.

These cities and towns, within a radius of approximately 15 miles from Boston, are fortunate in having about 50 miles of boulevards and parkways. These are under the jurisdiction of the Metropolitan District Commission.

The financing of these boulevards and parkways is provided for by annual legislative appropriations and by assessments on the thirty-eight cities and towns comprising the parks district.

For a number of years following the establishment of the Metropolitan Park System, the State's share in the cost of these boulevards and parkways was derived from annual revenue. Beginning with the year 1921, the Legislature appropriated, as the State's share, certain amounts from the annual receipts from motor vehicle fees. Since the establishment of the Highway Fund in the treasury department in 1926 the appropriations have been made from that source.

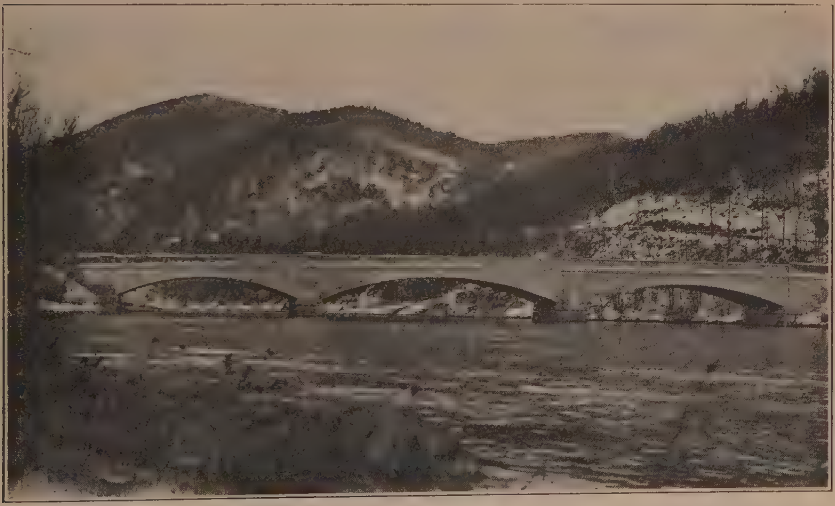

FIG. 24. — BRIDGE ON STATE HIGHWAY, MOHAWK TRAIL, CROSSING DEERFIELD RIVER, CHARLEMONT

Three-span concrete arch, total length 305 feet; built in 1913

The State's share has been appropriated for use under the direction of the Metropolitan District Commission. The State's share now constitutes half of the cost of a boulevard or parkway project.

The total amount of State funds which have been expended for these boulevards and parkways since 1894, including interest and bond payments, has been more than $11,000,000, a material benefit to a district, which in extent is nearly as large as some counties in the State.

In addition the State has expended within the cities and towns of the Metropolitan District for the construction and maintenance of State highways a total of more than $6,000,000.

Summary and Outstanding Figures

The Commonwealth of Massachusetts has made a very substantial contribution to the highway improvements in the State in a period of thirty-five years, from 1893 to the end of 1928. In summary, the following data is significant.

State Highways

State highways laid out to end of 1928, 1,609 miles.

State highways completed to end of 1928, 1,587 miles.

Many miles of these highways have been reconstructed during this period, newer types replacing the older, but this represents present mileage in use and annually maintained by the State.

Town and City Roads

The State's co-operation in constructing certain town and city roads, under provisions of various laws, the maintenance of which, after completion, rests on the towns, has, in this period, resulted in the construction of a large mileage, as follows:

Town and City Roads Constructed in Co-operation

	Miles
Small towns	570
Provisions of chapter 90, General Laws, and previous authority	1,395
Special acts and in western counties	240
Total	2,205

Town Roads Maintained by State (Chapter 81, General Laws).

Annually the maintenance of roads in 166 towns, having valuations less than $4,000,000, is done under the jurisdiction of the Department. This includes 8,050 miles.

The State, therefore, has charge of the maintenance of about 9,637 miles of highways, 1,587 miles of State highway and 8,050 miles of town roads, and in addition, during a period of years, has constructed 2,205 miles of local roads, — a total of 11,842 miles involving the State, being nearly half of all the road mileage within the Commonwealth.

The mileage of excellent roads in this State, including both State and municipal highways, is summarized as follows, the hard-surface types including cement concrete, dual, bituminous macadam and bituminous concrete, granite block, brick and sheet asphalt:

	Hard Surface (Miles)	Other Surface (Miles)	Total (Miles)
Towns	1,646.8	15,712.7	17,359.5
Cities	2,095.3	3,306.1	5,401.4
Total	3,742.1	19,018.8	22,760.9
Metropolitan parkways and boulevards	91.2	44.3	135.5
State highways	1,276.5	331.5	1,608.0
Grand total	5,108.8	19,394.6	24,504.4

The total annual expenditures by the State and municipalities for highways is a very imposing figure. The following tabulation represents the outlay met by current revenue, or receipts, the figures for municipalities being for 1927 and for State in 1928:

Municipalities:	
39 cities	$25,594,700
79 towns (over 5,000 population)	8,829,700
237 towns (under 5,000 population)	7,409,100
Total	$41,833,500
Counties (approximately)	2,000,000
Metropolitan district	1,500,000
State (approximately)	12,500,000
Total annual expenditures for highways	$57,833,500

The complete total of expenditure by the State for highway improvements within the area of the Metropolitan Parks District is as follows:

Maintenance of boulevards and parkways, plus interest and bond payments, since 1894, approximately	$11,000,000
State highways within the cities and towns of this district, construction and maintenance	6,150,000
Under special acts	2,500,000
Under chapter 90, General Laws	750,000
Total	$20,400,000

The cumulative expenditures by the Department and its predecessors for highways and bridges from 1893 to and including 1928 is as follows:

State Highways:		
Construction	$33,325,390	
Reconstruction and maintenance	51,231,346	
Total		$84,556,736
City and Town Highways:		
Chapter 90, General Laws	$12,496,100	
Chapter 81, General Laws (section 26)	5,535,380	
Small towns	1,410,750	
Western counties, etc.	3,762,100	
Total		23,204,330
Special Acts		3,835,230
Grand total		$111,596,296

Discussion

Mr. Edgar S. Dorr: I have heard some criticism of the State highway bridges because there was no provision for the safety of pedestrians. I would like to inquire if any such provision is intended on the State highways?

Mr. Dean: Some provision has been made for pedestrians on a good many bridges, and more of this will be done in the future than in the past, but out in the country, where the houses are far apart, it doesn't seem warranted to go to any large expense to build sidewalks. Under the law the Department cannot build sidewalks on State highways. It can build only between curbs, but the towns and cities, if they wish, may build sidewalks on the State roads, with a permit from the Department, and, of course, such a permit will always be granted.

Mr. French: I should like to raise a similar question as to whether some place cannot be provided for the pedestrian to walk instead of the roadway. It is a very serious problem. When we drive through the country in the evening it is pretty difficult sometimes to see pedestrians, and I wonder that there are not more accidents.

Question: I should like to ask about the nature of the maintenance crews, whether they are to any extent single-man crews with small sections or a larger gang with larger sections? We have all read of the single man on the French highway, with his little pile of broken stone. I wish Mr. Dean would give us some idea as to the size of gang he finds economical.

Mr. Dean: If the gentleman doesn't object, I will do just as I would if I were in the office. I will refer him to Mr. Delano, Maintenance Engineer.

Mr. Delano: The single-man patrol is not used because the chances are that he would have to do a lot of walking during the day to keep busy. A gang of two or three men under the supervision of a foreman, to do what is required, — place a guard rail or patch a section of roadway, — a foreman with a small gang for light work, and larger groups for the heavier type of work, is found to be most efficient.

Question: What is Mr. Dean's idea of the super-highway for groups of cities, like the proposed Boston–New York group?

Mr. Dean: I think that Mr. Winsor and I and some of the rest of you will never see the particular super-highway between Boston and New York. I think it is a great deal like the dream of the old toll road. The cost of building the super-highway is way beyond the cost of building a railroad, and I don't believe a super-highway owner will ever make a penny or get his road finally completed.

Mr. Bond: I wonder if Mr. Dean can tell us anything about the washboard effect in gravel roads?

Mr. Dean: Those washboard effects in gravel roads started when automobiles got so that there were more than fifty a day passing over a road. I think every superintendent of streets in the State had his theory of what made that washboard effect. Very eminent engineers — three or four that I could name — each explained what caused that effect, but each had a different explanation, and I don't think any one today can explain the washboard effect caused on the gravel road by automobile traffic. It seems to start with a slight washboard and then increase daily. I'd like to answer your question but I give it up.

Question: I'd like to ask Mr. Dean his opinion of the maximum desirable width for a State highway and a thoroughfare. There has been a great deal in the newspapers recently advocating roads up to 40 to 60 and more feet. Some of the western streets have got to 200 feet in width.

Mr. Dean: I think a 40-foot road would be very desirable a great many days in the year on some roads traveled the most, as, for instance, the Newburyport Turnpike. On widths greater than 40 feet, on through roads like the Newburyport Turnpike or the Worcester road, the same condition would exist that maintains on Morton Street in Boston, which has a roadway 80 feet in width, and part of it more than that, and the result is that the traffic is all over the road and there is no greater traffic capacity than that afforded by a well-regulated four-way road.

QUESTION: I would like to ask Mr. Dean if the State Department of Public Works takes the initiative in making any portion of the State highways through ways?

MR. DEAN: The Department has established only one State highway as a through way, that is, the Newburyport Turnpike. Others have been under consideration, but there are different conditions on other roads, and it has not yet been decided to make any other roads through ways.

MR. C. HOWARD: I am not desirous of taking much time, but I would like to say that in twenty years' constant travel about the upper and middle portions of the Cape, by various roads from Boston, I have found that the State highways have been a good job, and the little embellishment of the banks, of which we have seen illustrations tonight, is all to the good. In some spots the shrubs are not doing so well, but a little further attention and a little more care in selection of certain growths will accomplish even that, and I say, "Good Luck!" This is a wealthy State and a wealthy community, and we are a wealthy people, so we ought to pay attention to things other than the purely utilitarian.

I shouldn't have risen except to offer that word of congratulation, and so say that in the vicinity I speak of — for some twenty miles up and down the Cape, and especially in the vicinity of Plymouth — there are contractors who get their sand and their fill and selected materials right along the State highway, and leave their paraphernalia and broken down tools lying around, and it has been an eyesore there for years. Possibly the time has arrived when provision might be made that the excavation shall not be made within 100 yards of the State highway, or shall be smoothed over, or something. These pits are surely an eyesore and look much worse than the original.

QUESTION: I would like to ask Mr. Dean about that highway of Mr. Ford's which he showed. As I have been over it, it seemed to me that there is considerably more of it than Mr. Ford made. It appears to be the same until one reaches the outskirts of Marlborough. I would like to ask if that is all the same character of pavement, and if it all cost $125,000 a mile, which is the figure, I believe, Mr. Dean gave.

MR. DEAN: Mr. Ford built about half of the dual type road and the State built the rest up to the outskirts of Marlborough, entirely at the expense of the State except, perhaps, $1,000 a mile paid back by

Marlborough. I don't remember the exact cost of the road, but should think it would be at least $75,000 a mile.

QUESTION: In this open texture asphalt, what is the advantage over the old type?

MR. DEAN: It gives a better tractive resistance. There is not so much danger of skidding. Every effort is made in the roads built today to get that open texture, and yet not sufficiently open so that water will stand on the pavement and get in underneath. The open texture is secured by using No. 1 stone in the top course and not much of a seal.

QUESTION: If once the stone is broken down doesn't it disintegrate more readily than the old type that had a seal?

MR. DEAN: I doubt it very much, because we have roads which have been down five years, built, of course, with the best of stone, with very good trap rock, and they have shown great wearing qualities. By the time it has worn down much probably a seal coat might have to go on, but that would not be for quite a good many years.

OF GENERAL INTEREST

ICE USED IN ERECTION OF FLAT-BOTTOMED TANKS

*By Waldo F. Pike**

The measuring and storage tanks in the new Crosby Hydraulic Laboratory of the University of Maine are large, flat-bottomed steel tanks resting on mastic beds practically flush with the floors of the building.

The tank plates were shipped to the job and assembled and riveted at their final location in the building. The bottom plates were placed on cribbing about three feet above the mat, so that the under side of the tank would be accessible for riveting and testing.

After the tanks were entirely riveted and caulked, the bottoms were tested while the tanks were still on the cribbing. The test was made by partially filling the tanks with water and noting the leaks. Leaky rivets were then caulked or cut out and redriven, and seams were welded and caulked until the bottoms were tight. It was necessary to get the bottoms absolutely tight before lowering the tanks to their final position on the mastic beds, because after the tanks were down the bottoms would be inaccessible from the under side.

The next step in the erection was to lower the tanks. This could not be done the whole way conveniently with jacks without some special devices which would be expensive. There would also be the risk of straining the seams during the process.

A cheap and simple method was used in which blocks of ice of uniform thickness were inserted under the tanks and the tanks jacked down until they rested upon these blocks. The blocks were then melted out, and tanks settled into position on the mastic bed. The melting of the ice was controlled by means of salamanders inside the tanks directly over the cakes of ice. These salamanders were made of large paint pails with holes broken through the lower part of the sides for a draft. They could be moved readily and were moved when their particular cake of ice was melting too fast.

During the melting of the ice the tanks were braced sidewise, and any lateral adjustments in the positions were taken care of at this time. The tanks were kept level during the lowering process by placing a small amount of water on the bottom and letting it act as a level.

There is little danger of injury to the workmen in this method, and there is also the advantage of economy, simplicity, the opportunity to make minor adjustments in location, and small risk of strain to the tank.

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* Of Cleverdon, Varney & Pike, Structural Engineers, Boston, Mass.

Testing Temperature Affects Strength of Concrete

*By Miles N. Clair**

According to tests made at the Engineering Experiment Station, Iowa State College, the strength obtained in a test of concrete is greatly influenced by the temperature of the concrete when tested. The strength was found to increase slowly from 130° F. down to 30° F. and rapidly from there to 0° F. Compression, modulus of rupture and pipe tests were made. The data refer to only one mix of concrete, and therefore are not conclusive, but they do indicate a possibility of variations of as much as 100 per cent for the range of testing temperatures given.

Details of the tests are given in the recently published Bulletin No. 93, entitled "Supporting Strength of Concrete Incased Clay Pipe." The major part of the bulletin, however, is given over to the investigation of the strength of concrete incased clay pipe. It was found from the tests that the clay tile and the concrete shell act almost independently of each other in carrying the load. A method of determining the supporting strength of any concrete incased clay tile is developed and curves given for convenient use.

Data on the effect on the strength of concrete specimens of the temperature at the time of testing, covering a larger range of temperatures and mixtures, are given in Bulletin No. 2825 of the University of Texas.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

NOVEMBER 20, 1929. — The regular meeting of the Boston Society of Civil Engineers was held in Chipman Hall at 7.15 P.M., and was called to order by the President, Frank E. Winsor. Two hundred and twenty members and guests were present.

The reading of the minutes of the meeting held on September 25, 1929, was omitted, as they were printed in the October JOURNAL. The regular October meeting was omitted.

The President reported the death of the following members: Herbert F. Pierce, died October 27, 1929, a member since May 20, 1891; William F. Williams, died October 1, 1929, a member since April 18, 1894; Lemuel Pope, died October 31, 1929, a member since May 18, 1887.

The Secretary reported for the Board of Government the names of those elected to membership:

Grade of Member: Abraham Charles Bolde, Candelario Calor Mota, William B. West.

Grade of Junior: Charles M. Anderson, John Haven Britt, Joseph P. F. Cavazzoni, Henry Cohen, Martin Rockwood Haven, Harold George Hersey, Toivo A. Holmstrom, Minas S. Kamilakis, Lawrence E. Kilpatrick, James J. Leahy, John W. Lymberg, Philip S. Metcalf, Coburn M. Richardson, Arnold E. Schaier, Bernard B. Sheridan, Joseph A. Smith, Merton E. Sylvester, Vance S. Tarr, Robert H. Verner.

Grade of Associate: Alexander B. Daytz.

Pursuant to the recommendation of the Board of Government, as presented by the Treasurer, the Society *Voted* that the Board of Government be authorized to use the current income from the Permanent

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* Of The Thompson & Lichtner Company, Boston, Mass.

Fund to such an extent as necessary in payment of the current expenses of the Society.

This matter will also be presented at the December meeting for final action.

The President then introduced as the speaker of the evening Mr. Arthur W. Dean, Chief Engineer of the Massachusetts Department of Public Works, who presented a paper on "Massachusetts Highways." After referring to the early road building projects of the turnpike era, a brief history of the Massachusetts Highway Commission preceded an outline of the powers and duties of the Department of Public Works relative to State highways and the co-operative work with cities, towns and counties in the improvement of their highways.

Modern road building by this State, including types of construction and maintenance features as well as bridge construction, and the financing of this work were presented. Lantern slides showed typical highway and bridge construction and maintenance work.

At the conclusion of the paper a number of questions were asked regarding this work.

The meeting adjourned about 9.15 P.M.

EVERETT N. HUTCHINS, *Secretary.*

Sanitary Section

DECEMBER 4, 1929. — The meeting of the Sanitary Section was held in the Library of the Engineering Societies of Boston, Inc., on Wednesday, December 4, 1929.

Preceding the meeting nineteen members attended dinner at Patten's Restaurant.

The meeting was called to order at 7.15 P.M. by the Chairman, who announced that word had been received that Prof. Charles E. Fuller, the scheduled speaker, was confined to his house by illness.

The Chairman then introduced Mr. Francis H. Kingsbury, Assistant Engineer, Massachusetts Department of Public Health, and Secretary of the Commission investigating the sanitary condition of Boston Harbor, authorized by chapter 29, Acts of 1929.

Mr. Kingsbury presented a very interesting discussion of the problems confronting the Commission, prefacing his remarks with a history of the sewerage of Metropolitan Boston, and outlining the methods to be followed in the current investigation. He also discussed the methods of correlating tests made in previous investigations with those made in 1929, and the changes in procedure which have come along with the years.

The talk was discussed by Prof. Dwight Porter.

The meeting of twenty-three members adjourned at 8.20 P.M.

GEORGE G. BOGREN, *Clerk.*

Designers' Section

DECEMBER 11, 1929. — The meeting was called to order at 6.15 P.M., by Hale Sutherland, chairman of the Section.

Professor Sutherland, after announcing a tentative program for the rest of the winter, introduced the speaker, Angus B. MacMillan, Chief Engineer of the Aberthaw Company, who spoke on "The Protection of Exposed Concrete Surfaces." Mr. MacMillan's remarks, based largely on his own observations and experiences, contained many suggestions of practical value to designing engineers and specification writers.

Many of the forty-two members and guests present asked questions in the discussion period which followed the paper.

The meeting adjourned at 7.25 P.M.

NORMAN P. RANDLETT, *Clerk.*

APPLICATIONS FOR MEMBERSHIP

[December 20, 1929]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

Chibaro, Anthony, Roslindale, Mass. (Age 25, b. Italy.) Graduate of Tufts Engineering School in 1928 with degree of B.S. in civil engineering. From July, 1928, to December was assistant resident engineer with Tuttle Construction Company; from July, 1927, to October, same year, was steel draftsman with Hay Foundry Iron Works in Newark, N. J.; at present with Stone & Webster Engineering Corporation as steel draftsman. Refers to *H. P. Burden, S. K. Cohen, J. A. Howe, F. N. Weaver, E. H. Wright.*

Fitzgerald, William H., Boston, Mass. (Age 19, b. Medford, Mass.) Student at Northeastern University. Refers to *H. B. Alvord, C. O. Baird, J. W. Ingalls, G. H. Meserve.*

Lamb, Joseph I., Wollaston, Mass. (Age 39, b. Hartford, Conn.) Graduate of Norwich Free Academy, Norwich, Conn. From 1912–1916 draftsman with Boston & Maine Railroad; 1916–23, designer with Aberthaw Construction Company; 1923 to date, concrete designer with Stone & Webster Engineering Corporation. Refers to *S. K. Cohen, H. P. Fessenden, J. A. Howe, S. W. Sweeney.*

Malkowski, Peter C., Salem, Mass. (Age 24, b. Salem, Mass.) Graduate of Northeastern Polytechnic as civil engineer in 1927, and as a structural engineer in 1928. Worked for Massachusetts Department of Public Works, Division of Highways, from June 1, 1927, to January 8, 1929; from March 6, 1929, to date, concrete and hydraulic designer, with Stone & Webster Engineering Corporation. Refers to *H. B. Alvord, C. O. Baird, S. K. Cohen, J. W. Ingalls, W. N. Wade.*

Olken, David, Cambridge, Mass. (Age 23, b. Woronowa, Russia.) Graduate of Massachusetts Institute of Technology in 1928, with degree of B.S. in architectural engineering. Since then has been employed as rodman with Dwight P. Robinson Company, and now as draftsman in office of Stone & Webster Engineering Corporation. Refers to *Harry Cikins, S. K. Cohen, J. A. Howe, W. H. Lawrence, Abraham Woolf.*

Palmer, Harold Alonzo, Waltham, Mass. (Age 27, b. Westfield, Mass.) Graduate of Tufts Engineering School with degree of S.B. in civil engineering, 1927. From June, 1927, to June, 1928, with Metropolitan District Water Supply Commission; from June, 1928, to September, with the Pitometer Company of New York; September, 1928, to February, 1929, with Massachusetts Department of Public Works; March, 1929, to date, with Stone & Webster Engineering Corporation, as structural steel draftsman. Refers to *R. E. Baker, S. K. Cohen, H. P. Fessenden, J. A. Howe.*

Ring, Chester Allen, Jr., Boston, Mass. (Age 29, b. Bangor, Me.) College education comprises three years at University of Maine and two years at McGill University. During these five years has worked for C. A. Ring Construction Company on pulp, paper and hydro-electric work. Designed and constructed hydroelectric station at Caribou, Me.; contracted for and constructed highway bridges for Maine, New Hampshire and Vermont Highway Departments; supervised and engineered the erection of seven steel bridges in Vermont after the flood. At present engineering the construction of both railway and highway bridges. Refers to *J. D. Campbell, J. E. Carty, M. T. Cook, E. A. Graustein.*

Van Name, Horace Austin, Cambridge, Mass. (Age 24, b. Staten Island, N. Y.) Graduate of Stuyvesant High School in 1923. During that summer worked with Kalman Steel Company; in 1925, entered Cornell and obtained degree in civil engineering in June, 1929. Every summer, except 1927 spent at Cornell

Surveying Camp, employed by McClintock-Marshall Company in the reinforced concrete department. After graduation became steel draftsman with Stone & Webster Engineering Corporation. Refers to *S. K. Cohen, L. S. Cowles, H. P. Fessenden, J. A. Howe.*

NEW MEMBERS

Juniors

Howard V. Allen, 538 Massachusetts Avenue, Boston, Mass.
Henry Cohen, 90 Gainsboro Street, Boston, Mass.
Martin R. Haven, 27 Havana Road, Worcester, Mass.
Harold G. Hersey, 69 Gainsboro Street, Boston, Mass.
Minas S. Kamilakis, 142 Warren Avenue, Boston, Mass.
Philip S. Metcalf, 55 Revere Street, Boston, Mass.
Arnold E. Schaier, 44 Highview Street, Norwood, Mass.
Vance S. Tarr, 168 Central Street, Somerville, Mass.

DEATH

Edwin H. Lincoln . .	Dec. 8, 1929

BOOK REVIEW[1]

"Construction Control by Service Contract," by L. M. Richardson, Manager of Construction, Morton C. Tuttle Company, Boston, 1929. Morton C. Tuttle Company. 9 x 12, 14 pages, charts, forms; distributed gratis.

This is the third and last of three pamphlets by officers of the Morton C. Tuttle Company on the general subject of construction costs. The two previous ones are entitled "Architects, Costs, and Contractors" and "Estimating Construction Costs." The latter was reviewed in the Journal for March, 1929, page 132 *et seq.*

The pamphlet under review presents an outline of the system of control used on construction jobs under a "service" or "cost-plus" contract. This form is usually the architect's bugbear, for he rarely is a practical construction man, and while a pay roll subdivision may be wildly interesting to the constructor, it leaves the architect lukewarm, not to say cold. And it is on this sort of contract that many arguments arise. Therefore it is of great moment to the designer of the structure, as well as to the owner, that cost-plus jobs be undertaken by constructors in whom the utmost confidence may be placed. As is well known, under a cost-plus-fee contract the savings, if any, are divided between the owner and the constructor, so that not only is it the efficient organization that will be able to save money on a job, but it is that organization that will know whether there are savings or not, and will be able to stop leaks before they affect the job adversely. It is the method of cost control that is described in the pamphlet under consideration.

Without going deeply into the subject, which is complex, the main principles as set forth by Mr. Richardson are as follows:

1. It is the owner's privilege to interest himself in the construction. He must therefore be given such information as he may require in an understandable form.
2. The progress of the work must be carefully planned and recorded, so that the lagging behind of any part will at once be detected.
3. Time and cost must be systematically controlled and periodically recorded.
4. The accumulative costs must be constantly checked with the estimated cost and probable loss or profit forecasted, so that corrective measures may be applied while the work is still in progress.
5. The field man must be informed, so that he may supervise intelligently. To this end a "job budget" of the quantities and prices as estimated must be given to the superintendent for his information.

Various forms are used for the above purposes, and these are illustrated in the pamphlet. The three most important are:

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[1] By Edward Grossman

1. The Controlling Purchase Schedule, which is a graph constructed before starting the job. On this are noted the following dates:

(*a*) When drawings are required for the various items of work.

(*b*) When prices are to be taken.

(*c*) When material is to be ordered.

(*d*) When material must be on the job.

2. The Progress Schedule, which is a graphical counterpart of the ordinary written schedule.

3. The Cost Tendency Chart, on which are plotted the costs on both sides of a datum line so that savings and losses may be determined. One chart is made every week during the life of a job.

In general, then, efficient construction consists of —

1. Careful planning.
2. Constant checking.
3. Constant forecasting of probable costs.

The system as described is not only interesting and ingenious, but workable. The careful reading and digesting of the pamphlet will pay the architect or engineer in a better viewpoint of the constructor's side of the problem, and will enable him to understand what a constructor is talking about when he talks costs. To so many designers cost is merely an academic subject, so that a general improvement along this line would be desirable.

INDEX

VOLUME XVI, 1929

ABBREVIATION: I. — Illustrated

Names of authors are printed in *italics*

PAGE

Aerial Surveys, the Economic Application of. *J. F. Bagley, Jr.* . I., Nov., 457
Air Transport Development, the Engine as Barometer of. *B. G. Leighton* . May, 312
Alvord, Henry B. Discussion of papers on Joint Standard Building Code . June, 344
American Arbitration Association; Draft of State Arbitration Act — Appendix of article on "Arbitration" . April, 184
American Bar Association; Uniform arbitration act — Appendix of articles on "Arbitration" . April, 188
American Concrete Institute; The 1928 Joint Standard Building Code . June, 327
American Society of Civil Engineers, Fall Meeting:
  Announcement of . Sept., 416
  Review of . Nov., 488
Anchorage. *C. Hale Sutherland* . I., June, 334
Andrews, L. E. Outstanding Developments in the Concrete Pavement Field of Today . March, 103
Annual Reports of the Society . April, 214
Arbitration. *Prof. Charles B. Breed* . April, 141
Archimedes. *Edward Grossman* . Oct., 450

Bagley, J. F., Jr. The Economic Application of Aerial Surveys . I., Nov., 457
Barrows, H. K. Discussion of The Development of the Mongaup River . I., May, 281
Bench Marks, tidal . Nov., 488
Berkey, Prof. Charles P. Discussion of papers on Engineering Geology as Applied to Location of Tunnels and Dams . Jan., 33
Bond and Anchorage. *C. Hale Sutherland* . I., June, 334
Boston Harbor and Vicinity, Tide Table, 1929 . March, 132
Bradbury, Richard R. Preliminary Investigations for the Scituate Tunnel of the Providence Water Supply . Jan., 18
Brask, Henry. An Old Stone Stair . I., Feb., 96
Breed, Prof. Charles B. Arbitration . April, 141

PAGE

Bridge, Rigid Form Construction in Westchester County, New York, Development. *Arthur G. Hayden* I., Sept., 392
Bridge Built by Blacksmith I., Feb., 97
Building Code, the 1928 Joint Standard Proposed by the American Concrete Institute June, 327
Building Regulations for Reinforced Concrete, the Evolution of Modern. *R. R. Zipprodt* June, 327

Cameron, Edward H. Discussion of papers on Joint Standard Building Code June, 342
Canavan, Ruth. Reference Work in the Field of Sanitary Engineering April, 204
Carollo, Tyler and Steyskal. Discharge over Side Weirs with and without Baffles I., March, 118
Clair, Miles N. Testing Temperature Affects Strength of Concrete Dec., 555
Clair, Miles N. Discussion of papers on Joint Standard Building Code June, 356
Concrete, Allowable Unit Stresses. *Walter C. Voss* June, 340
Concrete, Testing Temperature Affects Strength. *Miles N. Clair* Dec., 555
Concrete Materials, Tests, Quality and Construction. *Prof. Dean Peabody, Jr.* June, 331
Concrete Pavement Field of Today, Outstanding Developments. *L. E. Andrews* March, 102
Constructor, Contractor or. *Edward Grossman* Jan., 53
Construction Costs, Estimating March, 132
Contractor or Constructor. *Edward Grossman* Jan., 53
Crosby, Irving B. Discussion of The Development of the Mongaup River May, 299
Crosby, Irving B. Electrical Exploration Methods for Location of Dams and Tunnels Jan., 21

Dams, Engineering Geology as Applied to Location of Tunnels and I., Jan., 1
Dams and Tunnels, Electrical Exploration Methods for Location of. *Irving B. Crosby* Jan., 21
Dean, Arthur W. Massachusetts Highways I., Dec., 493
Development of the Mongaup River. *William F. Uhl* I., May, 239
Diagonal Tension. *C. Hale Sutherland* I., June, 334
Diamond Drill Borings for the Swift River Dams. *N. LeRoy Hammond* Jan., 14
Discharge over Side Weirs with and without Baffles. *Richard G. Tyler, John A. Carollo and Norman A. Steyskal* I., March, 118
Dorr, Edgar S. Discussion of Massachusetts Highways Dec., 550

Eaton, Arthur C. Discussion of the Development of the Mongaup River May, 287
Economic Application of Aerial Surveys. *J. F. Bagley, Jr.* I., Nov., 457
Electrical Exploration Methods for Location of Dams and Tunnels. *Irving B. Crosby* Jan., 21

PAGE
Engine, the, as Barometer of Air Transport Development May, 312
Engineers in Public Service. *Edward Grossman* May, 320
Estimating Construction Costs March, 132
Evolution of Modern Building Regulations for Reinforced Concrete. *R. R. Zipprodt* June, 327

Fahlquist, Frank E. Subsurface Explorations for the Location of the Wachusett-Swift Tunnel I., Jan., 1
Flat Slabs, Reinforced Concrete Columns and Walls and Footings. *C. E. Nichols* June, 338
Flectural Computations, etc. *C. Hale Sutherland* I., June, 334
Fowler, Frederick N. The Economic Application of Aerial Surveys Nov., 469
Freeman Fund Traveling Fellow in Czecho-Slovakia Nov., 489
Frontinus, the Water Commissioner. *Edward Grossman* Sept., 417

Geology (Engineering) as Applied to Location of Tunnels and Dams I., Jan., 1
Graustein, Edward A. Discussion of the Development of the Mongaup River May, 289
Grossman, Edward. Archimedes Oct., 450
Grossman, Edward. Contractor or Constructor Jan., 53
Grossman, Edward. Engineers in Public Service May, 320
Grossman, Edward. Frontinus, the Water Commissioner Sept., 417
Grossman, Edward. Herbert Spencer June, 374

Halsey, M. N. Discussion of Traffic Control Engineering Feb., 68
Hammond, N. LeRoy. The Economic Application of Aerial Surveys I., Nov., 478
Hammond, N. LeRoy. Diamond Drill Borings for the Swift River Dams Jan., 14
Hayden, Arthur G. Rigid Frame Bridge Construction in Westchester County, New York, Development I., Sept., 392
Hersum, L. M. Discussion of papers on Joint Standard Building Code June, 345
Highway Surfacing, the Hot Mix Type. *Howard C. Holden* March, 112
Highways, Massachusetts. *Arthur W. Dean* I., Dec., 493
Holden, Howard C. The Hot Mix Type of Highway Surfacing March, 112
Holleran, L. G. Development of Parks and Parkways in Westchester County, New York I., Sept., 381
Hosmer, George L. Field Method of Adjusting a Transit I., March, 131
Hot Mix Type of Highway Surfacing. *Howard C. Holden* March, 112
Howe, J. W. Discussion of papers on Engineering Geology as Applied to Location of Tunnels and Dams Jan., 32
Hydraulic Experimentation — announcing series of lectures March, 135

Ice Used in Erection of Flat-bottomed Tanks. *J. Waldo Pike* Dec., 554
Industrial Wastes Pollution of Streams. *Robert Spurr Weston* I., June, 358

PAGE

Johnson, Lewis J. Discussion of Westchester County Park Development . . . . Sept., 407
Joint Standard Building Code, 1928, Proposed by the American Concrete Institute . . . . June, 327

Kennison, Karl R. Discussion of the Economic Application of Aerial Surveys . . . . I., Nov., 475
Kennison, Karl R. Discussion of papers on Engineering Geology as Applied to Location of Tunnels and Dams . . . . Jan., 33

Lane, Alfred C. Discussion of papers on Engineering Geology as Applied to Location of Tunnels and Dams . . . . Jan., 31
Leighton, B. G. The Engine as the Barometer of Air Transport Development . . . . May, 312
Luzon Triangulation, Northern. *Elliott B. Roberts* . . . I., May, 301

McClintock, Miller. Traffic Control Engineering . . . . Feb., 61
Massachusetts Arbitration Act — Appendix of article on Arbitration April, 181
Massachusetts Highways. *Arthur W. Dean* . . . . . I., Dec., 493
Moment Coefficients, etc. *C. Hale Sutherland* . . . . I., June, 334
Mongaup River Development. *William F. Uhl* . . . . I., May, 239
Moore, Lewis E. Discussion of Traffic Control Engineering . . Feb., 74
Morris, F. K. Discussion of papers on Engineering Geology as Applied to Location of Tunnels and Dams . . . . Jan., 28

New York Arbitration Act — Appendix of article on Arbitration . April, 175
Nichols, C. E. Flat Slabs, Reinforced Concrete Columns and Walls and Footings . . . . June, 338
Nichols, C. E. Discussion of papers on Joint Standard Building Code June, 346

Outstanding Developments in the Concrete Pavement Field of Today. *L. E. Andrews* . . . . March, 103

Parks, Westchester County Development. *L. G. Holleran* . . I., Sept., 381
Peabody, Jr., Prof. Dean. Concrete Materials, Tests, Quality and Construction . . . . June, 331
Pier Construction for the Mid-Hudson Bridge at Poughkeepsie, New York. *J. W. Rollins* . . . . I., Oct., 423
Pike, J. Waldo. Ice Used in Erection of Flat-bottomed Tanks . Dec., 554
Poughkeepsie, New York, Bridge-pier Construction. *J. W. Rollins* . I., Oct., 423
Proceedings of the Society:
Jan., 56; Feb., 98; March, 135; April, 208; May, 323; June, 377; Sept., 416; Oct., 453; Nov., 489; Dec., —.
Providence Water Supply, Preliminary Investigations for the Scituate Tunnel. *Richard R. Bradbury* . . . . Jan., 18
Purrington, Wallace F. Discussion of papers on Joint Standard Building Code . . . . June, 343

PAGE

Reference Work in the Field of Sanitary Engineering. *Ruth Canavan* April, 204
Reidy, Maurice A. Discussion of papers on Joint Standard Building Code . . . . June, 351
Reinforced Concrete, the Evolution of Modern Building Regulations for. *R. R. Zipprodt* . . . . June, 327
Reinforced Concrete Columns and Walls and Footings. *C. E. Nichols* June, 338
Roberts, Elliott B. The Northern Luzon Triangulation . . . I., May, 301
Rockwood, E. F. Discussion of papers on Joint Standard Building Code . . . . June, 349
Roemer, E. W. Discussion of papers on Joint Standard Building Code June, 347
Rudolfs, Willem. Sludge Digestion . . . . . . I., Jan., 37

Sanitation, Summer Camp. *Elmer W. Campbell* . . . . Feb., 82
Schwamb, Peter. Memoir . . . . Jan., 55
Scituate Tunnel of the Providence Water Supply, preliminary investigations. *Richard R. Bradbury* . . . . . . Jan., 18
Shear and Diagonal Tension, etc. *C. Hale Sutherland* . . . I., June, 334
Side Weirs with and without Baffles, Discharge of. *Richard G. Tyler, John A. Carollo and Norman A. Steyskal* . . . . I., March, 118
Sludge Digestion. *Willem Rudolfs* . . . . . . I., Jan., 37
Spencer, Herbert. *Edward Grossman* . . . . . . June, 374
Steyskal, Carollo and Tyler. Discharge over Side Weirs with and without Baffles . . . . I., March, 118
Spofford, Prof. Charles M. Discussion of Westchester County Park Development . . . . Sept., 407
Spofford, Prof. Charles M. Discussion of the Economic Application of Aerial Surveys . . . . Nov., 467
Stone Stair, An Old . . . . I., Feb., 96
Steam Pollution, by Industrial Wastes, Some Examples. *Robert Spurr Weston* . . . . I., June, 358
Summer Camp Sanitation. *Elmer W. Campbell* . . . . Feb., 82
Sutherland, C. Hale. Design, Flectural Computations and Moment Coefficients, Shear and Diagonal Tension, Bond and Anchorage I., June, 334
Sutherland, C. Hale. Discussion of papers on Joint Standard Building Code . . . . June, 346
Swift River Dams, Diamond Drill Borings for. *N. LeRoy Hammond* Jan., 14

Tanks, Flat-bottomed, Ice Used in Erection of. *J. Waldo Pike* . Dec., 554
Terzaghi, Dr. Charles. Discussion of papers on Engineering Geology as Applied to Location of Tunnels and Dams . . . Jan., 27
Testing Temperature Affects Strength of Concrete. *Miles N. Clair* . Dec., 555
Tidal Bench Marks . . . . Nov., 488
Tide Table, Boston Harbor and Vicinity, 1929 . . . . March, 132
Traffic Control Engineering. *Miller McClintock* . . . . Feb., 61
Transit, Field Method of Adjusting. *George L. Hosmer* . . . I., March, 131
Triangulation, Northern Luzon. *Elliott B. Roberts* . . . I., May, 301
Tucker, Francis Carlile. Memoir . . . . . . April, 207

		PAGE
Tunnels and Dams, Engineering Geology as Applied to Location of. *Frank E. Fahlquist*	I., Jan.,	1
Turner, Howard M. Discussion of the Development of the Mongaup River	May,	288
Tyler, Richard G., John A. Carollo and Norman A. Steyskal. Discharge over Side Weirs with and without Baffles	I., March,	118
Uhl, William F. The Development of the Mongaup River	I., May,	239
Voss, Walter C. Allowable Unit Stresses in Concrete	June,	340
Voss, Walter C. Discussion of papers on Joint Standard Building Code	June,	347
Voss, Walter C. Discussion of papers on Engineering Geology as Applied to Location of Tunnels and Dams	Jan.,	32
Wachusett-Swift Tunnel, Subsurface Exploration for the Location of. *Frank E. Fahlquist*	I., Jan.,	1
Westchester County, New York, Development of Parks and Parkways. *L. G. Holleran*	I., Sept.,	381
Westchester County, New York, Rigid Frame Bridge Construction. *Arthur G. Hayden*	I., Sept.,	392
Weston, Robert Spurr. Some Examples of Pollution of Streams by Industrial Wastes	I., June,	358
Whitecross, Frank. Discussion of papers on Joint Standard Building Code	June,	354
Whitney, Frank O. Discussion of Traffic Control Engineering	Feb.,	76
Williams, William F. Discussion of Traffic Control Engineering	Feb.,	69
Winsor, Frank E. Discussion of papers on Engineering Geology as Applied to Location of Tunnels and Dams	Jan.,	25
Zipprodt, R. R. The Evolution of Modern Building Regulations for Reinforced Concrete	June,	327

Vol. XVI DECEMBER, 1929 No. 10

BOSTON SOCIETY OF CIVIL ENGINEERS

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INDEX TO ADVERTISERS

	PAGE
Aspinwall & Lincoln, 46 Cornhill, Boston	iii
Associated Architects Printing & Supply Co., 25 Pearl St., Boston	x
Barbour, Frank A., Tremont Building, Boston	iv
Barrows, H. K., 6 Beacon St., Boston	iii
Bay State Dredging and Contracting Co., 62 Condor St., East Boston	x
Beattie, Roy H., 209 Bedford St., Fall River	ix
Berry Drafting Service, 101 Tremont St., Boston	iv
Bishop, J. W., Co., 100 Erie St., Cambridge	iv
Blair, Isaac, & Co., Inc., 433 Harrison Ave., Boston	xii
Boston Insulated Wire & Cable Co., Dorchester	vi
Bruno & Petitti, Contractors, 18 Tremont St., Boston	iv
Buff & Buff Co., Jamaica Plain	ix
Coleman Bros., 245 State St., Boston	ix
Crandall Engineering Co., 134 Main St., Cambridge	xi
Crosby, Irving B., 6 Beacon St., Boston	iii
Eastern Bridge and Structural Co., Worcester	viii
Fay, Spofford & Thorndike, 44 School St., Boston	iii
Fuller & McClintock, 170 Broadway, New York	iii
Gibson & Williams, Inc., 65 Long Wharf, Boston	ix
Gow Company Inc., 956 Park Square Building, Boston	vi
Granite Paving Block Mfrs.' Assoc., 31 State St., Boston	xiv
Holzer, U., Inc., 333 Washington St., Boston	vii
Jackson & Moreland, Park Square Building, Boston	iii
Main, Inc., Chas. T., 201 Devonshire St., Boston	ii
Makepeace, Inc., B. L., 387 Washington St., Boston	Back cover
Metcalf & Eddy, Statler Building, Boston	iii
Monks & Johnson, 99 Chauncy St., Boston	iv
New England Foundation Co., Inc., 38 Chauncy St., Boston	ix
Old Corner Book Store, 50 Bromfield St., Boston	ix
Palmer Co., Inc., John E., 1012 Old South Building, Boston	ix
Pittsburgh Testing Laboratory, 101 Tremont St., Boston	iv
Portland Stone Ware Co., 80 Federal St., Boston	v
Rideout, Chandler & Joyce, 130 Broad St., Boston	ix
Scully Co., 238 Main St., Cambridge	vii
Simpson Bros. Corpn., 77 Summer St., Boston	v
Smith, B. F., & Co., Merchants Bank Building, 79 Milk St., Boston	ix

PAGE
Standard Oil Co. of New York, 31 St. James Ave., Boston xii
Stone & Webster, Inc., 49 Federal St., Boston xiii
Stuart, T., & Son Co., Newton, Mass. xi
Thompson & Lichtner, The, Co., Inc., Statler Building, Boston . . . iii
Thorpe, Lewis D., 6 Beacon St., Boston iii
Tucker, Edward A., Co., 101 Milk St., Boston iv
Warren Foundry and Pipe Co., 201 Devonshire St., Boston vii
Weston & Sampson, 14 Beacon St., Boston iii
Whitman & Howard, 89 Broad St., Boston iii
Worcester, J. R., & Co., 79 Milk St., Boston iii
Wright & Potter Printing Co., 32 Derne St., Boston x

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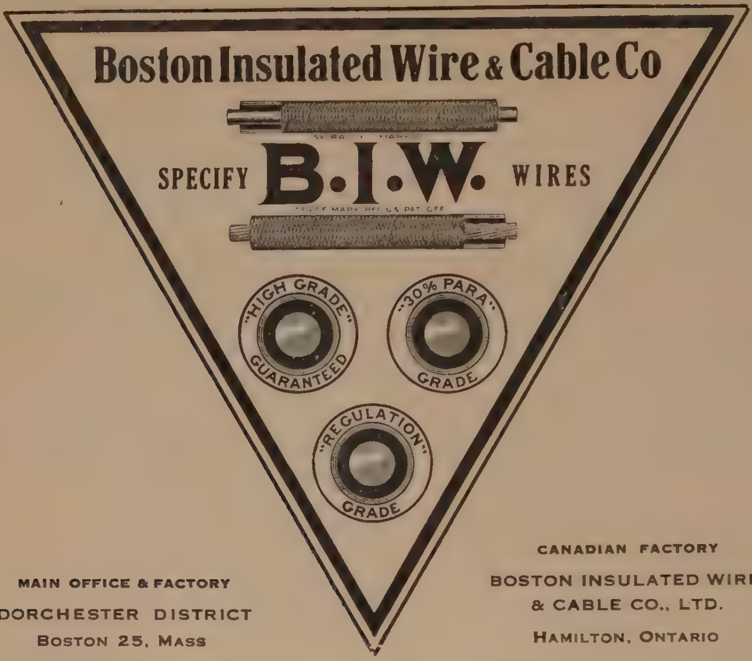

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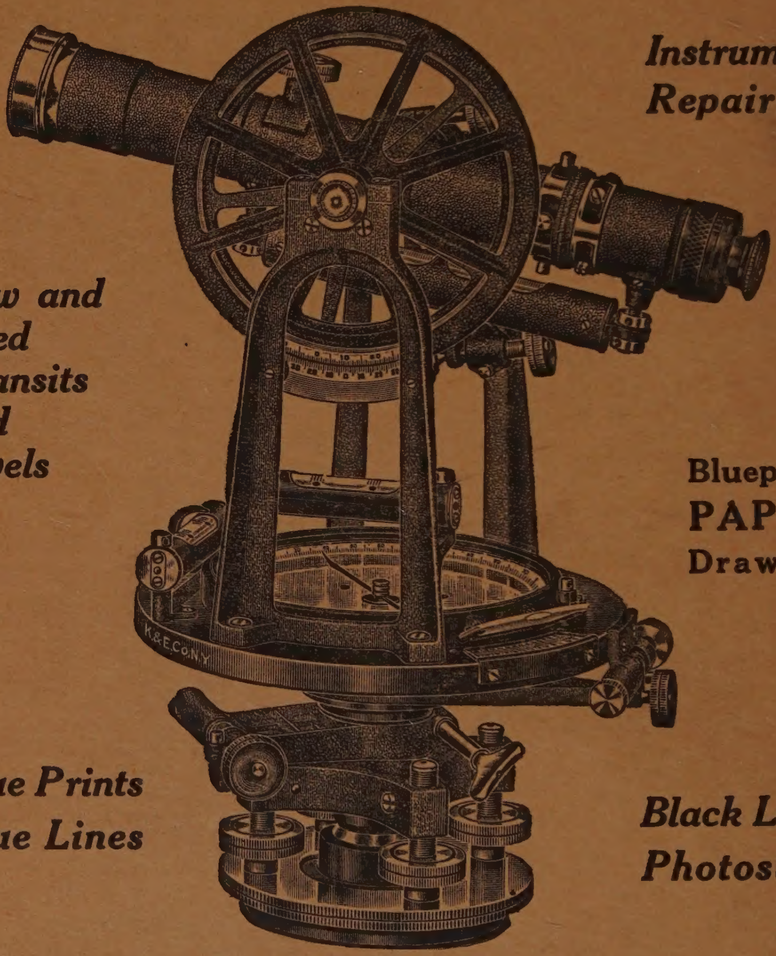

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